Stratus Consulting

Assessment Plan
Rio Tinto Mine Site NRDA

Public Release Draft Report

Prepared for:

Rio Tinto Mine Trustee Council

Prepared by:

Stratus Consulting Inc.
PO Box 4059
Boulder, CO 80306-4059
(303) 381-8000

September 1, 2004
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Acronyms

ALC	aquatic life criteria
AM	Assessment Manager
AMD	acid mine drainage
AOC	Administrative Order on Consent
ARC	Atlantic Richfield Company
BHPS	Bureau of Health Protection Services
BIA	Bureau of Indian Affairs
BWQP	Bureau of Water Quality Planning
CCC	criterion continuous concentration
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
CMC	criterion maximum concentration
COC	chain-of-custody
CWA	Clean Water Act
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DQOs	data quality objectives
DVIR	Duck Valley Indian Reservation
E&E	Ecology and Environment
EPA	U.S. Environmental Protection Agency
ERS	Emergency Response Section
ERS-TAT	ERS Technical Assessment Team
FTL	Field Team Leader
GIS	geographic information systems
GPS	global positioning system
HEA	habitat equivalency analysis
MCL	Maximum Contaminant Level
MCLGs	MCL Goals
MDL	method detection limit

MOA	Memorandum of Agreement
MWH	Montgomery Watson Harza
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDEP	Nevada Division of Environmental Protection
NDOW	Nevada Division of Wildlife
NOAA	U.S. National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRDA	natural resource damage assessment
PEC	probable effect concentration
PI	Principal Investigator
PM	Project Manager
PRPs	potentially responsible parties
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCDP	Restoration and Compensation Determination Plan
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RPD	relative percent difference
RSD	relative standard deviation
RTWG	Rio Tinto Working Group
SAPs	sampling and analysis plans
SDWA	Safe Drinking Water Act
SDWR	Secondary Drinking Water Regulation
SEM	simultaneously extracted metals
SOP	standard operating procedure
SOW	Statement of Work
SRM	standard reference material
TEC	threshold effect concentration
TSA	Technical System Audit
USFS	U.S. Department of Agriculture, Forest Service
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey

1. Introduction

1.1 Statement of Purpose

The Shoshone-Paiute Tribes of Duck Valley (Tribes), the U.S. Department of the Interior (DOI) Bureau of Indian Affairs (BIA) and U.S. Fish & Wildlife Service (USFWS), the U.S. Department of Agriculture, Forest Service (USFS), and the Nevada Division of Environmental Protection (NDEP) (collectively, the Trustees) are conducting a natural resource damage assessment (NRDA) for releases of hazardous substances from the Rio Tinto Mine in Elko County, Nevada. The purpose of the NRDA is to make the public whole for natural resource losses that have resulted from hazardous substance releases from the mine.

This NRDA has been initiated pursuant to the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) [42 USC § 9607(f)], the Clean Water Act (CWA) [33 USC §§ 1321(f)(4)-(5)], the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 CFR Part 300 Subpart G], and the DOI's NRDA regulations at 43 CFR Part 11. CERCLA and the CWA hold those parties responsible for releases of hazardous substances liable for "damages for injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing such injury, destruction, or loss resulting from such a release" [42 USC § 9607(4)(C)]. Federal, state, and tribal governmental entities having trust responsibility over the affected natural resources are entitled to bring such a claim.

The purpose of this Assessment Plan is to describe the Trustees' planned approach to determine and quantify injuries to natural resources and to determine the appropriate type and amount of natural resource restoration required to make the public whole as a result of those injuries. This plan is also intended to communicate these intentions to the public and the potentially responsible parties (PRPs) so that they can participate in the assessment process. The PRPs currently identified at the mine are Atlantic Richfield Company (ARC), Cleveland Cliffs Iron Company (Cliffs), E.I. du Pont de Nemours and Company (du Pont), Teck Cominco American Incorporated (Teck Cominco), and George Wallace and Company (Wallace). Four of these companies, ARC, Cliffs, du Pont, and Teck Cominco, constitute the Rio Tinto Working Group (RTWG).

This Assessment Plan is divided into six chapters. Chapter 1 introduces the plan by describing the authority and process by which the Trustees have undertaken the development of the assessment. Chapter 2 discusses the geography of the assessment area, the history of the mine, the nature of the releases, and the natural resources involved. Chapter 3 confirms that natural resources in question have been exposed to hazardous substances released from the mine. In Chapter 4, the approaches for assessing injuries to different natural resources are presented.

Chapter 5 discusses how the Trustees plan to conduct restoration planning and scaling. Chapter 6 provides the Quality Assurance Project Plan.

1.2 Trusteeship Authority

Under the DOI regulations, assessment plans must include a statement of the authority for asserting trusteeship for those natural resources addressed in the Assessment Plan [43 CFR § 11.31(a)(2)]. A general description of the natural resource authority asserted by the trustees is given below. In addition, each trustee may have co-trustee authority over natural resources listed within the trusteeship of another trustee.

1.2.1 Shoshone-Paiute Tribes

According to federal regulations, Indian tribes may act as trustees for "natural resources, including their supporting ecosystems, belonging to, managed by, controlled by, or appertaining to such Indian tribe" [40 CFR § 300.610]. The tribal chairmen, or other designated representatives, are "authorized to act when there is injury to, destruction of, loss of, or threat to natural resources, including their supporting ecosystems as a result of a release of a hazardous substance" [40 CFR § 300.610].

The Shoshone-Paiute Tribes of Duck Valley (the Tribes) assert trusteeship for all natural resources within the Duck Valley Indian Reservation (DVIR). The Tribes are designated as the Lead Administrative Trustee for the NRDA.

1.2.2 Federal trustees

CERCLA and the CWA authorize the President to recover, on behalf of the public, damages for injuries to natural resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States [42 U.S.C. §§ 9607(f)(1), 9601(16); 33 U.S.C. § 1321(f)(5)]. The President has designated federal natural resource trustees in the NCP [40 CFR § 300.600]. Natural resources under federal trusteeship are land, fish, wildlife, biota, air, water, groundwater, drinking water, and other resources that are "managed or controlled" by the United States, including supporting ecosystems resources [40 CFR § 300.600].

The Secretary of the Interior is designated as trustee for all natural resources managed or controlled by the DOI, including their supporting ecosystems [40 CFR § 300.600(b), (b)(2), and (b)(3)]. The statutory bases for DOI's trusteeship include, but are not limited to, the Migratory Bird Treaty Act (16 U.S.C. § 703 *et seq.*), the Bald Eagle Protection Act (16 U.S.C. § 668 *et seq.*), the Fish and Wildlife Coordination Act (16 U.S.C. § 661 *et seq.*), the Clean Water Act (33 U.S.C. § 1251 *et seq.*), and the Endangered Species Act (16 U.S.C. § 1531 *et seq.*).

The Secretary may also serve as trustee on behalf of an Indian tribe for natural resources for which an Indian tribe would otherwise act as trustee [40 CFR § 300.600(b)(2)]. Such trusteeship is impressed on the United States by statute and case law. "It is the policy of the Department of the Interior to recognize and fulfill its legal obligations to identify, protect, and conserve the trust resources of federally recognized Indian tribes and tribal members . . ." (DOI, 1995). The nature and scope of these trust responsibilities have more recently been restated in *Navajo Nation v. United States*, 263 F.3d 1325 (Fed. Cir. 2001). Although the Tribes are acting as Lead Administrative Trustee for its natural resources, the Secretary of the Interior, acting through the BIA, also has trusteeship.

The Secretary of Agriculture is an authorized trustee under the NCP for those natural resources "on, over, or under" national forest lands [40 CFR § 300.600(b)(3)], namely, the Humboldt-Toiyabe National Forest. The Secretary of Agriculture delegated Trustee authority to the Chief of the Forest Service [7 CFR § 2.60(a)(42)], and authority has been further delegated to the Regional Forester as per Forest Manual § 2164.04 C-3.

1.2.3 State trustees

State trustees may act on behalf of the public for "natural resources, including their supporting ecosystems, within the boundary of a state or belonging to, managed by, controlled by, or appertaining to such state" [40 CFR § 300.605]. The governor of a state may designate a lead trustee to coordinate all state trustee responsibilities with other state trustee agencies and with response activities. NDEP has been designated the state trustee by the governor of Nevada.

1.3 Natural Resource Damage Assessment Process

An NRDA is a procedure by which trustees of natural resources seek to determine compensation for natural resource injuries that have not been or are not expected to be addressed by response actions. The measure of such compensation is the "cost of restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and the services those resources provide" and may also include the "compensable value of all or a portion of the services lost to the public for the time period from the . . . release until the attainment of the restoration, rehabilitation, replacement, and/or acquisition of equivalent of the resources and their services to baseline" [43 CFR § 11.80(b)].

The DOI has promulgated regulations for conducting an NRDA related to hazardous substance releases at 43 CFR Part 11. Trustees are not required to follow the procedures, but doing so provides them with a legal evidentiary status of a rebuttable presumption in an administrative or judicial proceeding [43 CFR § 11.10]. The Trustees intend to follow these NRDA regulations in the Rio Tinto Mine NRDA.

The four major phases in the NRDA process are the Preassessment Phase, the Assessment Plan Phase, the Assessment Phase, and the Post-Assessment Phase.

1.3.1 Preassessment Phase

The Preassessment Phase of an NRDA is the first step in conducting an NRDA. Trustees must rapidly review available data and determine whether or not to proceed with an assessment [43 CFR § 11.13(b)], and then document this decision in a Preassessment Screen Determination [43 CFR § 11.23(c)]. The Preassessment Screen Determination for the Rio Tinto site has been completed and was released to the public on February 11, 2003 (Shoshone-Paiute Tribes of Duck Valley et al., 2003). In accordance with the criteria at 43 CFR § 11.23(e) the Preassessment Screen demonstrated that

- a discharge or release of a hazardous substance has occurred
- natural resources for which the Trustees may assert trusteeship under CERCLA have been or are likely to have been adversely affected
- the quantity of the release is sufficient to potentially cause injury
- data to perform an assessment are available or obtainable at a reasonable cost
- response actions do not or will not sufficiently remedy the injury to natural resources without further action [43 CFR § 11.23(e)].

Thus the Trustees concluded that they should proceed with an NRDA to develop a damage claim under 42 USC § 9607.

1.3.2 Assessment Plan Phase

If the decision is made to perform an NRDA, the Trustees prepare an Assessment Plan. The purpose of the Assessment Plan is to ensure that the assessment is well planned and conducted systematically, and that the selected methods for assessment are cost-effective [43 CFR § 11.13(c)]. According to DOI regulations, the Assessment Plan confirms exposure of natural resources (Chapter 3 of this plan), describes the objectives of any testing and sampling for injury or pathway determination (Chapter 4 of this plan), and provides a Quality Assurance Plan (QAP) to ensure quality control in testing and sampling [43 CFR § 11.31(c)(2)] (Chapter 6 of this plan).

The Assessment Plan may also include a Restoration and Compensation Determination Plan (RCDP). However if insufficient information is available to develop the RCDP, it may be completed at a later time before the completion of Injury Determination and Quantification, which take place in the Assessment Phase (Section 1.3.3) [43 CFR § 11.31 (c)(4)]. The Trustees will develop an RCDP at a later time. This Assessment Plan contains an approach to conduct restoration planning and scaling (Chapter 5).

1.3.3 Assessment Phase

The Assessment Phase is when the evaluation of injuries and damages is conducted. The DOI regulations identify two types of NRDAs, Type A and Type B. Because the Trustees chose to conduct a Type B assessment (see Section 1.4 of this document), the parts of a Type B assessment are described here.

1. **Injury determination**: The first part of the Assessment Phase determines what natural resources have been injured as a result of the release(s) of a hazardous substance(s) [43 CFR § 11.13(e)(1)]. It also involves determining the pathway, or route, through which the hazardous substance was transported from the source to the injured resource [43 CFR § 11.61(c)(3)].

2. **Injury quantification**: The second part of the Assessment Phase quantifies the determined injuries in terms of the “loss of services that the injured resource would have provided had the discharge or release not occurred” [43 CFR § 11.13 (e)(2)]. The extent and degree of injuries, the ability of the resource to recover, and the reduction in services are included in the quantification of injuries [43 CFR § 11.71(c)]. The “interdependent services” provided by natural resources are identified to “avoid double counting in the Damage Determination phase and to discover significant secondary services that may have been disrupted by the injury” [43 CFR § 11.71(b)(4)].

3. **Damage determination**: The third part of the Assessment Phase determines the appropriate monetary compensation for the injuries [43 CFR § 11.13 (e)(3)]. Damages are measured as the cost of “restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and the services those resources provide” and may also include the value of the services lost to the public from the time of the release to the reestablishment of the services to baseline conditions [43 CFR § 11.80(b)].

1.3.4 Post-Assessment Phase

The Post-Assessment Phase is the final step in the NRDA process. After the assessment is complete, the Trustees produce an Assessment Report containing the results of the NRDA [43 CFR § 11.90]. The Trustees may then seek recovery of damages from the PRPs [43 CFR § 11.91], and such damages may include direct and indirect costs “necessary to complete all actions identified in the selected alternative for restoration, rehabilitation, replacement, and/or acquisition of equivalent resources” [43 CFR § 11.83(b)]. If damages are awarded, an account is established for the damages recovered [43 CFR § 11.92], and a Restoration Plan is developed and implemented using the recovered damages [43 CFR § 11.93].

1.4 Decision to Perform a Type B Assessment

Under the DOI’s NRDA regulations, the Trustees can elect to perform a Type A or a Type B NRDA [43 CFR § 11.33]. This section documents the Trustees’ decision to perform a Type B assessment.

Type A procedures are “simplified procedures that require minimal field observation” [43 CFR § 11.33(a)]. An authorized official may use a Type A assessment only if the release occurs in a coastal/marine or Great Lakes environment [43 CFR § 11.34(a)], making a Type A NRDA inapplicable for the mine assessment area.

The alternative to a Type A procedure is a Type B procedure. Type B procedures require “more extensive field observation than the Type A procedures” [43 CFR § 11.33(b)]. A Type B assessment consists of three phases: injury determination, injury quantification, and damage determination [43 CFR § 11.60(b)] (see Section 1.3). The Trustees may incur reasonable costs in the assessment phase of the Type B damage assessment [43 CFR § 11.60(d)].

The Trustees have concluded that the use of Type B procedures is justified at the Rio Tinto Mine.

1.5 Response Actions

1.5.1 Past and ongoing response actions at the site

The site was identified as potentially hazardous and entered into the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) in 1979 (Shoshone-Paiute Tribes of Duck Valley et al., 2003). A preliminary assessment and a site investigation Hazardous Rating System package were completed in 1982. In 1986, NDEP contacted the U.S. Environmental Protection Agency (EPA) Emergency Response Section (ERS) for assistance. An EPA ERS Technical Assessment Team (ERS-TAT) performed a Preliminary Site Assessment and recommended that no emergency response actions should be pursued. A subsequent investigation in 1989, also performed by the ERS-TAT, evaluated the possibility of a removal action and recommended that remediation be conducted at the site to evaluate alternatives to reduce hazardous substance releases from the site. A site investigation was completed in 1991, and in 1996 the EPA deferred National Priority List (NPL) status for the site. The RTWG entered into an Administrative Order on Consent (AOC) with the NDEP in September 1996 to address the environmental and safety concerns at the mine. This led to a series of cleanup activities that helped to improve surface water quality but was not sufficient to consistently eliminate exceedences of aquatic life criteria at downstream monitoring locations (RTWG & MWH, 2002b).

Based on a site inspection of the mine attended by representatives of the EPA, USFS, BIA, NDEP, and the Tribes in 1999, it was concluded that previous remedial efforts were incomplete and did not effectively eliminate acidic and metal laden effluent from the mine tailings (Shoshone-Paiute Tribes of Duck Valley et al., 2003). An assessment was conducted in 2000 to determine eligibility for NPL listing. The EPA deferred listing the site on the condition that a remedial investigation, a feasibility study, and selection of remedy be completed and that the EPA, NDEP, the RTWG, and the Tribes negotiate an agreement for a permanent solution. Negotiations between EPA, NDEP, the RTWG, and the Tribes ultimately resulted in an AOC between the NDEP and the RTWG (RTWG, 2001).

The 2001 AOC (RTWG, 2001) incorporated a Statement of Work (SOW) to carry out a remedial investigation, feasibility study, and selection of remedy (RTWG & MWH, 2001). The objectives of the SOW include assessing sources of contamination at the mine, assessing the extent of current impacts, developing feasible alternatives for remediation, and selecting a preferred alternative. Implementation of the SOW is ongoing (see Section 2.2 of this plan for more detail on response actions; RTWG & MWH, 2003a).

1.5.2 NRDA coordination with response actions

To the extent possible, an NRDA should be conducted in coordination with any investigations undertaken as part of NCP response actions, particularly a Remedial Investigation/Feasibility Study (RI/FS) [43 CFR § 11.31(a)(3)]. The Trustees realize that implementing a protective remedy is of primary importance for protection of natural resources. However, based on current information, it is not likely that remediation alone will achieve full restoration of injured natural resources and the services provided by those resources. Moreover, the timing and nature of the remedy selected will affect the extent and duration of continuing injuries to natural resources. Therefore, the amount of restoration required will depend, to a degree, on the remedy selected, the timing of its implementation, and the degree to which it is successful. In general, a less protective remedy will result in greater residual injury to natural resources, a consequent need for more extensive restoration to return the resources to their baseline condition, and greater compensation to make the public whole for the additional services it has lost. For these reasons, the Trustees have coordinated, and will continue to coordinate, with the RTWG and the State of Nevada on response actions and the RI/FS process.

To this end, and because coordination between the Trustees and the parties to the 2001 AOC (RTWG, 2001) is an essential component of a cost-effective damage assessment, the EPA, the State of Nevada, and the Tribes signed a Memorandum of Agreement (MOA; State of Nevada DEP et al., 2002) that forms a technical work group for the purpose of reviewing and commenting on the major deliverables and work plans produced by the RTWG under the SOW (RTWG & MWH, 2001). The MOA also provides a procedure for resolving conflicts between the parties to the MOA.

The goals of such coordination are to avoid duplication, reduce costs, and achieve dual objectives where possible. At a minimum, the Trustees intend to consider the objectives of removal actions, RI/FS activities, and remedial actions during the continued planning and implementation of the NRDA. Whenever possible, the Trustees will explicitly coordinate damage assessment activities with other investigations and will ensure that appropriate consideration is given to parties undertaking remediation or restoration activities that satisfy the Trustees' NRDA objectives.

1.6 Public Review and Comment

This Assessment Plan is available for public review and comment by PRPs; other natural resource trustees; other affected federal, state, or tribal agencies; and any other interested members of the public for a period of 30 days [43 CFR § 11.32(c)(1)]. While not required under state law, the Trustees believe that a public comment period is appropriate and will provide an opportunity for involvement by PRPs, other governmental agencies, and the public in this important matter. It may also provide the Trustees with new information and ideas that they may incorporate into their assessment. The Trustees are, therefore, providing a period of 30 calendar days for public comment. Comments must be received within 30 days from the date the notice of availability is published in the Federal Register. Comments may be submitted in writing to:

Mr. Wayne Nordwall
Western Regional Director
U.S. Bureau of Indian Affairs
Western Regional Office
P.O. Box 10
Phoenix, AZ 85001

For overnight mail only:
400 North Fifth Street
Phoenix, AZ 85004
Tel: 602-379-6600

The Trustees may amend the Assessment Plan, and any significant amendments will be made available for public review [43 CFR § 11.32(e)].

2. Description of the Assessment Area

2.1 Geographic Areas

2.1.1 Definitions

For the purposes of this Assessment Plan the terms “mine” and “assessment area” are defined as follows:

Mine: The Rio Tinto Mine (mine) property in Elko County, Nevada, and associated features, including the historic Rio Tinto mine, mill, and townsite; hillside tailings; the upper heap leach pad; and Mill Creek tailings heaps and ponds (Shoshone-Paiute Tribes of Duck Valley et al., 2003).

Assessment area: “The area or areas within which natural resources have been affected directly or indirectly by the . . . release of a hazardous substance and that serves as the geographic basis for the injury assessment” [43 CFR § 11.14(c)], namely, the Mill Creek and Dry Creek watersheds, the watershed of the East Fork of the Owyhee River (including areas within the Duck Valley Indian Reservation), and any other areas containing natural resources potentially injured by hazardous substances released from the mine.

2.1.2 Description

In 2001, under the AOC between NDEP and the RTWG, the Rio Tinto Mine site was renamed the Rio Tinto Mine Project Site and divided into Areas A and B (RTWG & MWH, 2001) (Figures 2.1 and 2.2). Area A generally comprises the mine and lands between the Dry and Mill Creek streambeds. Area B includes all areas within the East Fork Owyhee River Basin from south of Wildhorse Reservoir Dam north and west to (and including) DVIR, with the exception of Mill Creek and Dry Creek downstream of the mine.

The mine is located on approximately 280 acres (Shoshone-Paiute Tribes of Duck Valley et al., 2003) at an elevation of 5,839 ft in northern Elko County, Nevada, south of Mountain City (USDA, 1990). The mine is surrounded by the Humboldt-Toiyabe National Forest of the USFS, at approximately 41°48’55” north and 115°58’40” west (USGS, 1986). Mill Creek, which serves as the main drainage for the mine (USDA, 1990), is located along the northern part of the mine site and flows approximately 1 mile before it joins the East Fork of the Owyhee River. The south side of the mine is bordered by Dry Creek, which drains portions of the townsite and plant area through an ephemeral channel (USGS, 1986). RTWG monitoring data indicate that Dry Creek flows only in late winter and during spring snowmelt (RTWG & MWH, 2002b).

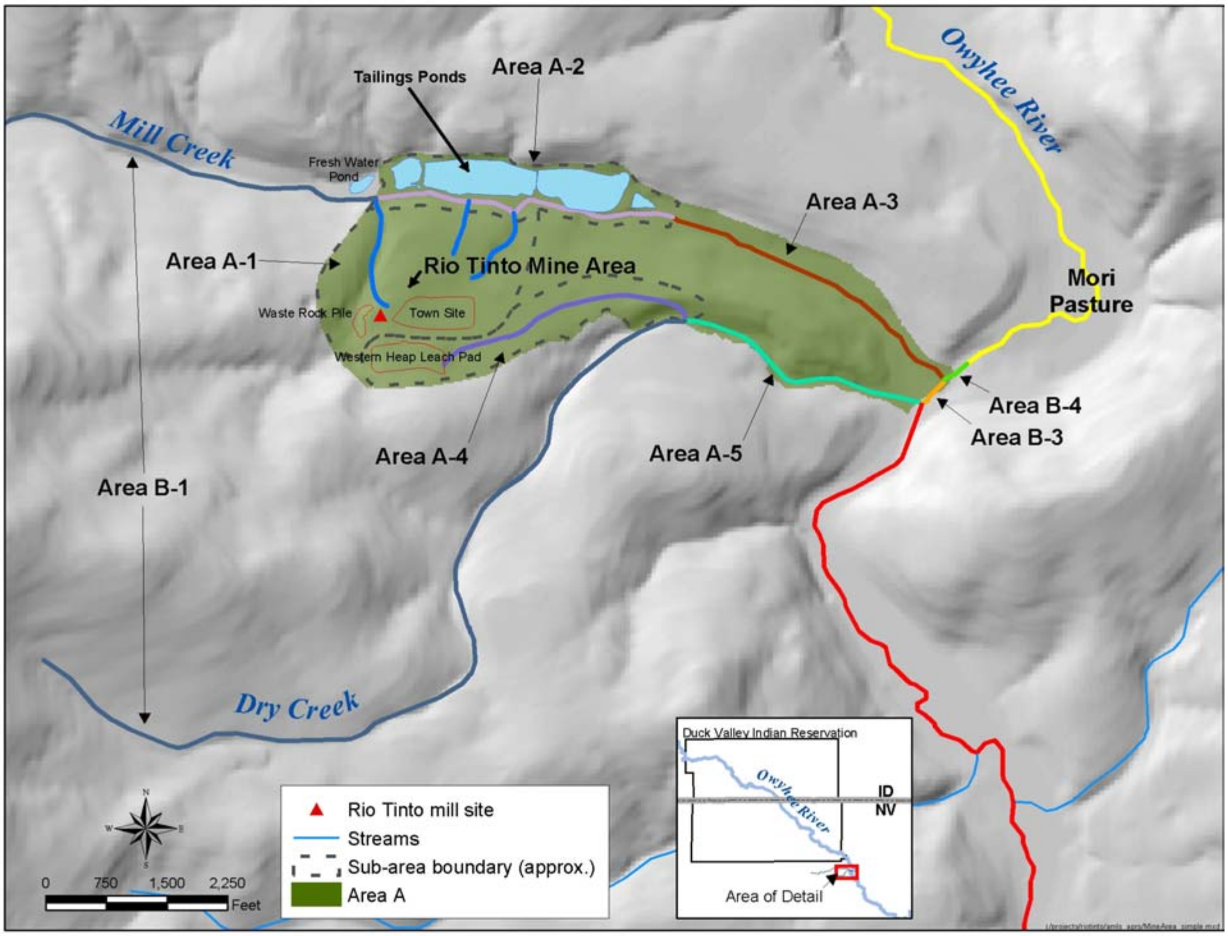

Figure 2.1. Rio Tinto Mine Project Area A and Areas B-1, B-3, and B-4.

Upstream of the Mill Creek confluence on the East Fork Owyhee River is Wild Horse Reservoir and Dam, which is operated by the BIA for the Duck Valley Indian Reservation Irrigation Project (USDA, 1990). Downstream of this confluence, the East Fork Owyhee River crosses into the DVIR and traverses the reservation in a northwest direction for approximately 34 miles before exiting at the northwest corner of the reservation. The East Fork Owyhee River continues to flow approximately 188 miles from where it enters the DVIR before it joins the Snake River in eastern Oregon.

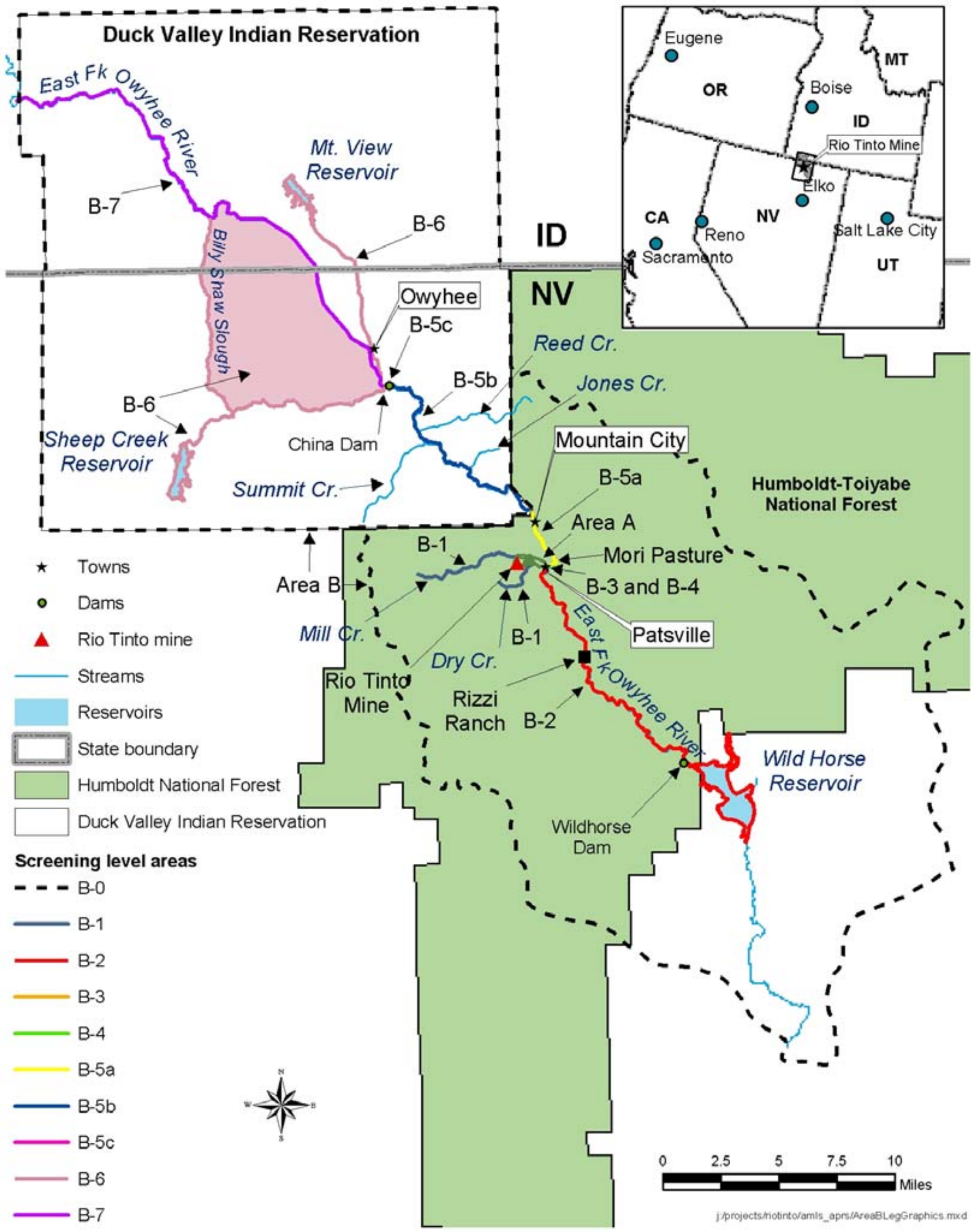

Figure 2.2. Rio Tinto Mine Assessment Area overview and Area B.

2.2 History of Rio Tinto Mine

Copper deposits were discovered at the mine site in 1931 by Samuel F. Hunt. The Mountain City Copper Co., a subsidiary of Anaconda Copper, operated the mine from 1932 through 1947, employing conventional underground mining techniques and a flotation mill to produce concentrate and high grade ore. Mill tailings were placed in the upper portion of the original Mill Creek Channel (RTWG & MWH, 2002b; Shoshone-Paiute Tribes of Duck Valley et al., 2003). During this period, Mill Creek was diverted from its original streambed to the Mill Creek diversion channel to reduce water flows through the tailing material (RTWG & MWH, 2002b). The property was abandoned in 1948 (RTWG & MWH, 2002b).

After changing hands several times following 1947, the property was sold in 1966 to George M. Wallace and Company (Wallace), who operated the site under an agreement with the Cliffs Copper Corporation (Cliffs). Wallace engaged in an acid-leaching operation from 1965 to 1967, to extract copper from water within the underground workings and to recover soluble copper from approximately 1 million tons of concentrator tailings in the Mill Creek Valley (RTWG & MWH, 2002b).

Wallace also leached mill tailings in the valley floor. The tailings were terraced and saturated with an acidic solution, then the leachate was pumped to a precipitating cone at the mill site (RTWG & MWH, 2002b). As part of the leach operation, Wallace constructed an embankment across Mill Creek to contain processed material in a new tailings pond. Leaching operations ceased sometime between 1967 and 1970 when further recovery became uneconomical.

There were also several operative changes during this period. An underground injection well was installed in 1970 to remove water accumulating in the underground mining areas so that mining operations could continue. A water treatment plant was used during the initial dewatering phase and the effluent was discharged to Mill Creek (RTWG & MWH, 2002b).

In 1972 Cliffs took over the operation in its entirety, until 1975 when it was sold to Cominco America (Shoshone-Paiute Tribes of Duck Valley et al., 2003). During this period, development of an in situ solution mining operation of a secondary ore zone began. Cliffs began dewatering the mine in January 1972, and dewatering operations continued until May 1973 (RTWG & MWH, 2002b). Sludge generated during the mine dewatering and water treatment was pumped into a sludge pond. During this development, ores were placed on leach pads for future copper recovery and heap leaching of these ores took place from 1973 to 1975, when operations were discontinued because of low copper prices and high costs (RTWG & MWH, 2002b). A National Pollutant Discharge Elimination System (NPDES) permit was issued in 1973 for the discharge of treated water into Mill Creek (USDA, 1990). Limited drilling exploration and geophysical and geological studies were conducted during 1975-1976. The site has remained inactive since 1977 (Shoshone-Paiute Tribes of Duck Valley et al., 2003; RTWG & MWH, 2002b).

During the 1980s and 1990s site investigations were conducted at the mine by RTWG members and regulatory agencies. Between 1986 and 2001, several remedial actions were completed. A section of the Mill Creek diversion channel was stabilized by Cliffs and DuPont in 1986. As part of a 1996 AOC, the RTWG prepared a Remedial Work Plan that addressed site safety, human health, and environmental concerns (RTWG & MWH, 2002b). Work elements identified in this Work Plan, such as lining of trenches, regrading of ponds and tailings piles, securing of mine shafts, and construction of diversion ditches, were completed in 1996 and 1997. Water monitoring was conducted for a 3-year period after the remedial action was completed. Additional remedial elements were completed from 1999 to 2001, including trench construction, lime treatment technology investigations, and pond installation and modification. In 2002 and 2003, the RTWG conducted pilot scale water treatment tests, installed monitoring wells, conducted a pump test to characterize shallow groundwater movement, and did additional work to remove scrap material and reinforce a wildlife protection net (RTWG & MWH, 2003a; State of Nevada DEP, 2004).

2.3 Hazardous Substances Released

2.3.1 Sources and releases

During the initial mining period, the mine produced an estimated 1,109,878 short dry tons of ore averaging 9.745% copper, 0.274 ounces per ton of silver, and 0.0057 ounces per ton of gold (RTWG & MWH, 2002b). Tailings were disposed of in the upper portion of Mill Creek and the creek was diverted. From 1965 to 1967 sulfuric acid was introduced into the underground workings and the resulting solution was pumped into a precipitation tank filled with scrap tin (Shoshone-Paiute Tribes of Duck Valley et al., 2003). One month after a fish kill was recorded in 1970, results of water samples collected by the Nevada Division of Wildlife (NDOW) from Mill Creek and the East Fork Owyhee River showed very high levels of copper (700 ppm) and highly elevated iron (Shoshone-Paiute Tribes of Duck Valley et al., 2003). In December 1974, a multiple day discharge of bright red effluent into Mill Creek and the East Fork Owyhee River occurred. Discoloration was noted at least 20 miles downstream of Mill Creek in the East Fork Owyhee River. Water samples showed elevated concentrations of copper, zinc, and iron (USDA, 1990).

Modeling developed by RTWG estimated that there are 1,137,250 cubic yards (2,243,839 tons) of tailings at the site (Shoshone-Paiute Tribes of Duck Valley et al., 2003). Seepage from the lower tailings dam was sampled in 1988 and 1989; it was found to have a pH of 2.7 and high concentrations of metals and trace elements (USDA, 1990). Samples collected from mine site tailings piles #3 and #4 by the EPA ERS-TAT showed elevated levels of arsenic, copper, selenium, silver, and zinc (Shoshone-Paiute Tribes of Duck Valley et al., 2003). In 1994, the North Diversion ditch was breached and water flowing from the ditch ran across the upper tailings pile into Mill Creek; field observations indicate that this flow mobilized metals and trace elements in the waste material and affected water quality in Mill Creek (RTWG & MWH, 2002b).

Releases of hazardous substances continue. Several sources at the mine currently release various hazardous substances into the water and sediment in Mill Creek and the East Fork of the Owyhee River. Principal sources of acid mine drainage (AMD) released into Mill Creek include surface runoff and/or seepage from the waste rock pile, hillside tailings piles No. 1 and No. 2, Ponds 3 and 4, and the Heap Leach Pad (RTWG & MWH, 2002b). Seepage from the mine waste material occurs on the south and east sides of Pond 4. The seeps on the south side of Pond 4 flow directly into Mill Creek, and the Pond 4 seepage is the main source of metal loading to Mill Creek (RTWG & MWH, 2002b).

Additional sources of hazardous substance releases from the mine may include, but are not limited to, other seeps passing through waste rock and overburden piles, surface water runoff and soil erosion, and adits, tunnels, pipes, channels, and shafts. Moreover, it is likely that soils and sediments contaminated by mine releases continue to re-release hazardous substances into the water bodies.

2.3.2 Hazardous substances released

Those hazardous substances, as listed in 40 CFR Part 302.4, that have been released include, but may not be limited to, the substances and compounds listed in Table 2.1.

AMD generated at the mine is formed when water percolates through mineralized rock made accessible and permeable by construction of the mining adits and through deposition of tailings and waste rock on the ground surface. Oxidation and hydration of sulfur and sulfur minerals in the main ore body and the discarded waste rock create sulfuric acid, ferrous sulfate, and other metal sulfates. AMD also typically contains the other hazardous substances listed in Table 2.1, because the sulfuric acid and low pH water leach the heavy metals from the ore (Stumm and Morgan, 1996). Furthermore, when the pH of the AMD is equal to or less than 2, it satisfies the corrosivity test of the Resource Conservation and Recovery Act (RCRA) [42 USC § 6921; 40 CFR § 261.22(a)(1)] and is incorporated as a hazardous substance under CERCLA [42 USC § 9601(14)(C); 40 CFR § 302.4(b)]. Seepage from the south and east faces of the tailings at the site are characterized by reduced pH values as low as 2.0 (Shoshone-Paiute Tribes of Duck Valley et al., 2003).

Table 2.1. Hazardous substances released from the Rio Tinto Mine

Hazardous substance	Information source on release
Arsenic and compounds	Shoshone-Paiute Tribes of Duck Valley et al., 2003
Cadmium and compounds	USDA, 1990 (Attachment 18)
Chromium and compounds	USDA, 1990 (Attachment 18)
Copper and compounds	Shoshone-Paiute Tribes of Duck Valley et al., 2003 USDA, 1990
Selenium and compounds	Shoshone-Paiute Tribes of Duck Valley et al., 2003
Sulfuric acid	Shoshone-Paiute Tribes of Duck Valley et al., 2003
Zinc and compounds	Shoshone-Paiute Tribes of Duck Valley et al., 2003 USDA, 1990

2.4 Potentially Affected Natural Resources

The DOI regulations define five categories of natural resources for purposes of assessing natural resource damages: surface water resources, groundwater resources, air resources, geologic resources, and biological resources. The following sections briefly describe each of these resource categories in the assessment area.

2.4.1 Surface water resources

Surface water resources in the assessment area include the water, streambed, and bank sediments of Mill Creek and the East Fork of the Owyhee River. These resources provide ecological services such as habitat for aquatic biota and a water supply for riparian vegetation habitat, and human use services such as irrigation for grazing lands and drinking water for livestock. Mill Creek and the East Fork Owyhee River are also important because they are a principal transport pathway by which hazardous substances are transported from the mine, exposing other resources.

In addition, the East Fork Owyhee River is a primary source of water for DVIR (USDA, 1990). The Tribes have had ancestral rights on the river for hundreds and perhaps thousands of years. The Tribal economy is subsistence based, and the river plays an integral role in the Tribal economy. It provides subsistence fishing, is an important source of irrigation water for grazing lands, and is a source of drinking water for livestock. The river also is important in various Tribal cultural activities, such as supporting the growth of willows used in traditional basket-making and other activities.

2.4.2 Groundwater resources

The mine site area contains both near-surface groundwater systems and a deeper bedrock system. The near-surface, unconfined aquifers are located in the area of the mine waste materials and the eastern end of Pond 4. The deep bedrock system exists within the underground mine working south of Mill Creek. Groundwater generally flows toward the Mill Creek valley and then to the east down the Mill Creek drainage in near-surface, unconfined groundwater systems (RTWG & MWH, 2002b). There are little available data characterizing the groundwater system elsewhere in the assessment area.

Groundwater resources in the assessment area provide human use and ecological services. Numerous private drinking water wells are located downstream of the mine and within the alluvial aquifer that is recharged by the East Fork Owyhee River (USDA, 1990; RTWG & MWH, 2002a). The Mountain City municipal water system draws water from a spring in Slaughterhouse Gulch approximately 7 miles north of Mountain City (RTWG & MWH, 2002a). Groundwater also serves to recharge surface waters, thereby providing important ecological services.

2.4.3 Air resources

Air resources near the mine may be affected by releases through blowing dust from the tailings ponds and other releases (USDA, 1990). At this time, the Trustees do not have sufficient data to indicate that an assessment of air resources would be cost-effective, and thus methods for evaluating injury to air resources are not discussed in this document. Pending additional information, the Trustees may determine that an assessment of air resources should be undertaken.

2.4.4 Geologic resources

Potentially exposed geologic resources include upland soils at the mine, riparian soils located in the floodplains of Mill Creek and the East Fork of the Owyhee River, and soils in areas irrigated with Mill Creek or East Fork Owyhee River water from downstream of the site. Upland soils at the mine include heap leach, tailings and waste rock piles, and areas to which hazardous substances have been transported via wind-blown dust, erosion, road building, or other site activities. Riparian soils along Mill Creek and the East Fork of the Owyhee River, which can become exposed during floods, are important in providing a medium for riparian vegetation, invertebrates, microbes, and other biota. Soils in fields irrigated with Mill Creek or East Fork Owyhee River water (USDA, 1990) can be exposed to hazardous substances released from the mine, potentially affecting the ability of the soil to provide an adequate medium for forage growth.

2.4.5 Biological resources

The Preassessment Screen Determination (Shoshone-Paiute Tribes of Duck Valley et al., 2003) states that potentially injured biological resources may include, but not be limited to:

- resident fish of various species
- benthic and epibenthic species
- other aquatic flora and fauna
- upland, riparian, riverine, and wetland fish and wildlife habitats
- migratory birds
- threatened or endangered species
- mammalian and avian species
- reptiles and amphibians, particularly the Columbia spotted frog, a candidate species for threatened or endangered species listing
- vegetation.

Approximately 150 plant species of concern were identified as likely to occur along the East Fork Owyhee River (Shoshone-Paiute Tribes of Duck Valley, 2004). Wildlife such as beaver (*Castor canadensis*) (USFS, 1990), deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and pronghorn (*Antilocapra americana*) are known to frequent areas of the East Fork Owyhee River corridor, and may ingest or otherwise come in contact with contaminated resources (Walker Research Group, Ltd., 2002b). A number of potentially injured aquatic biota have existed in the assessment area, including, but not limited to, a number of species of fish (particularly trout), benthic invertebrates, and amphibians. Rainbow trout (*Oncorhynchus mykiss*; also referred to as "redband trout") have been observed in Mill Creek (Johnson, 2000), and both game [rainbow trout, brown trout (*Salmo trutta trutta*), yellow perch (*Perca flavescens*), and bowcut trout (cutthroat trout (*Oncorhynchus clarki clarki*) /rainbow trout hybrid)] and nongame species [mottled sculpin (*Cottus bairdii*), speckled dace (*Rhinichthys osculus*), redside shiner (*Richardsonius balteatus*), bridgelip sucker (*Catostomus columbianus*) and longnose dace (*Rhinichthys cataractae*)] have been recently observed in the East Fork Owyhee River (Johnson, 2001). Johnson (2001) reports that in the past, mountain whitefish (*Prosopium williamsoni*), northern squawfish (*Ptychocheilus oregonensis*), and salmon (unknown species) were observed in the East Fork Owyhee River, but these species were not observed in 2000. The river was stocked with rainbow trout from 1937 through 1972, with surplus brown trout in 1994, and with rainbow trout in 1995 (Johnson, 2001).

2.4.6 Cultural resources

The East Fork of the Owyhee River and its tributaries are of great importance to the Tribes. The river provides for their perpetual existence on their homeland of the Duck Valley Indian Reservation, and the Tribes' members rely heavily on the physical and spiritual connection with the river (Shoshone-Paiute Tribes of Duck Valley, 2004).

The East Fork Owyhee River and associated riparian habitat is a source of many resources used by the Tribes for cultural and subsistence purposes. Herbs, berries, and other plants are gathered for use as food, medicine, and crafts. Resources are also used for spiritual purposes such as "sweats," a ceremony in which water is poured over heated rocks to create steam that is inhaled by the participants throughout the ceremony. The Shoshone-Paiute culture has a deep respect for the earth; any desecration of the earth violates the fundamental principles of the Tribes' spiritual and religious views. The protection and maintenance of the land and resources associated with the reservation for future generations are elementally tied to the Tribe's culture and heritage (Shoshone-Paiute Tribes of Duck Valley, 2004).

3. Confirmation of Exposure

This chapter presents data confirming that natural resources have been exposed to hazardous substances released from the mine. The DOI NRDA regulations state that an assessment plan should confirm that:

> at least one of the natural resources identified as potentially injured in the preassessment screen has in fact been exposed to the released substance [43 CFR **§** 11.37(a)].

A natural resource has been exposed to a hazardous substance if “all or part of [it] is, or has been, in physical contact with . . . a hazardous substance, or with media containing the . . . hazardous substance” [43 CFR **§** 11.14(q)]. The DOI regulations also state that “whenever possible, exposure shall be confirmed using existing data” from previous studies of the assessment area [43 CFR **§** 11.37(b)(1)].

Hazardous substances released from the mine include various toxic metals such as copper and zinc, and acidity in the form of sulfuric acid (see Chapter 2). The following sections provide confirmation of exposure to these hazardous substances, based on a review of the available data, for surface water and sediment resources in the assessment area.

Groundwater, air, geologic, and biological resources may also be exposed to hazardous substances released from the mine. Although data have been collected regarding hazardous substances in groundwater (RTWG & MWH, 2002a, 2002b), in geologic resources (RTWG, 2002), and in biological resources (Shoshone-Paiute Tribes of Duck Valley, 2004), confirmation of exposure for these resources is not presented here.

3.1 Data Sources

Data for assessing the exposure of surface water and bed sediment to hazardous substances have been collected by multiple parties. The data collected by these various groups were compiled by the RTWG in the Rio Tinto Mine Remediation Project Environmental Database (RTWG, 2002). The version of this database used in this Assessment Plan is current through December 2002.[1]

1. More recent data collected by NDEP are available at http://ndep.nv.gov/bwqp/snakemap.html, but these data were not relied upon in this assessment plan.

Samples have been collected in the Mill Creek drainage and in the drainage of the East Fork of the Owyhee River (including areas within reservation boundaries). Areas A and B (see Chapter 2) were further subdivided into hydrologic subareas to facilitate comparisons between reaches (RTWG & MWH, 2002b, 2003b) (see Figures 2.1 and 2.2). These same subareas are used in this confirmation of exposure.

3.1.1 Surface water data

In Area A, RTWG conducted quarterly sampling from 1995 through 2000, and monthly since then. NDEP conducted several sampling events between 1980 and 2001, focusing on Mill Creek and the tailings ponds. Samples have also been collected by the USFS, the EPA, the Shoshone-Paiute Tribes, the U.S. Geological Survey (USGS), Cliffs Copper Corporation (1972-1975), and the NDOW (1971-1975).

Most of the Area A data are compiled in RTWG & MWH (2002a). More recent data collected by the RTWG are in RTWG & MWH (2003b). Documentation regarding data collection methods and data quality assurance and control varies. Most of the older data are not accompanied by supporting Quality Assurance/Quality Control (QA/QC) information. Database quality assurance procedures by MWH (Montgomery Watson Harza) are unspecified.

In Area B, Cliffs Copper collected various water quality data from 1971 through 1974. The RTWG has collected water quality data from 1995 to the present. NDEP Bureau of Water Quality Planning (BWQP) data are available from STORET, and include data from 1966 to 2002. The Tribes collected water quality data for the Rio Tinto Mine/Mill Reclamation Audit (Shoshone-Paiute Tribes of Duck Valley, 2000) and for the Cultural Resources Assessment (Shoshone-Paiute Tribes of Duck Valley, 2004). Various other Area B surface water studies have been conducted by EPA, USFS, NDOW, and USGS.

3.1.2 Sediment data

RTWG sampled East Fork Owyhee River sediment in 2002 (RTWG & MWH, 2003b). The Tribes sampled East Fork Owyhee River sediment in 1999 (Shoshone-Paiute Tribes of Duck Valley, 2000) and 2002 (Shoshone-Paiute Tribes of Duck Valley, 2004). EPA sampled Mill Creek and East Fork Owyhee River sediment in 2000.

3.2 Surface Water Resources

To confirm exposure of surface water resources, the Trustees compared water quality measurements upstream and downstream of influence from the mine. For Mill Creek, the Trustees compared data from subareas B-1 and A-3 (see Figure 2.1), and for the East Fork Owyhee River, the Trustees compared data from subareas B-2 and B-4 (see Figure 2.2) (RTWG, 2002).

It is evident that surface water in Mill Creek downstream of the mine has been exposed to hazardous substances. For example, the minimum pH value recorded in the upstream reach is 5.9, and the minimum value recorded downstream of the mine is 2.4 (Figure 3.1).

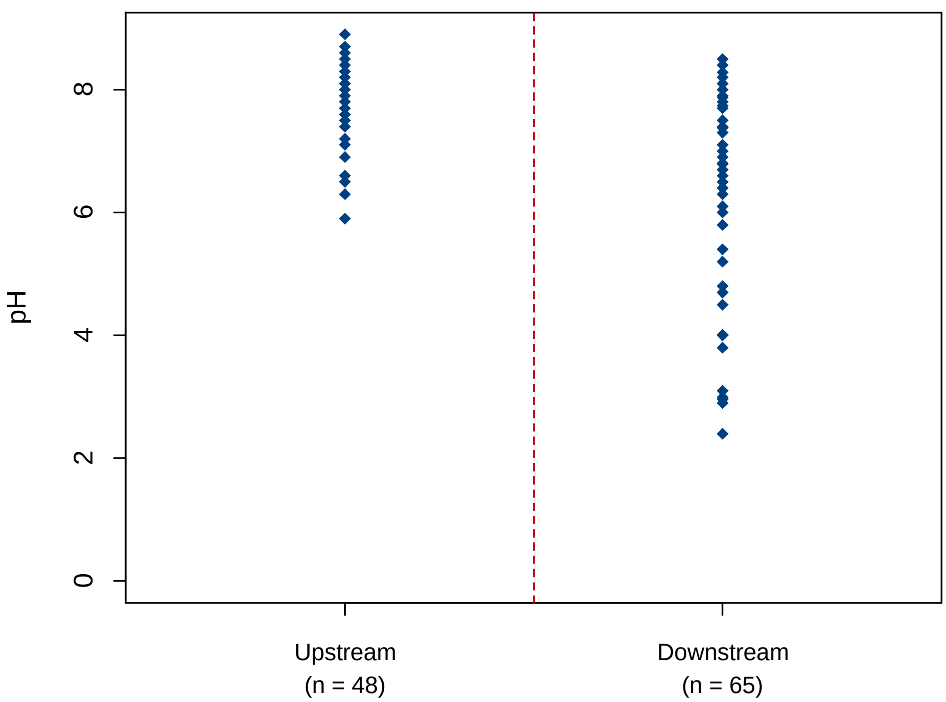

Figure 3.1. Surface water pH in Mill Creek upstream and downstream of influence from the Rio Tinto Mine.

Source: RTWG, 2002.

Copper concentrations are also elevated downstream of the mine relative to concentrations in potential reference areas. Maximum dissolved copper concentrations measured in Mill Creek downstream of the mine were up to four orders of magnitude greater than those measured upstream of the mine (Figure 3.2). Copper was detected in all (91) of the samples from the downstream reach compared to 45 out of 66 samples from the upstream reach. The maximum detected copper concentration measured in the upstream Mill Creek reach was 0.045 mg/L, compared to 700 mg/L in the downstream reach.

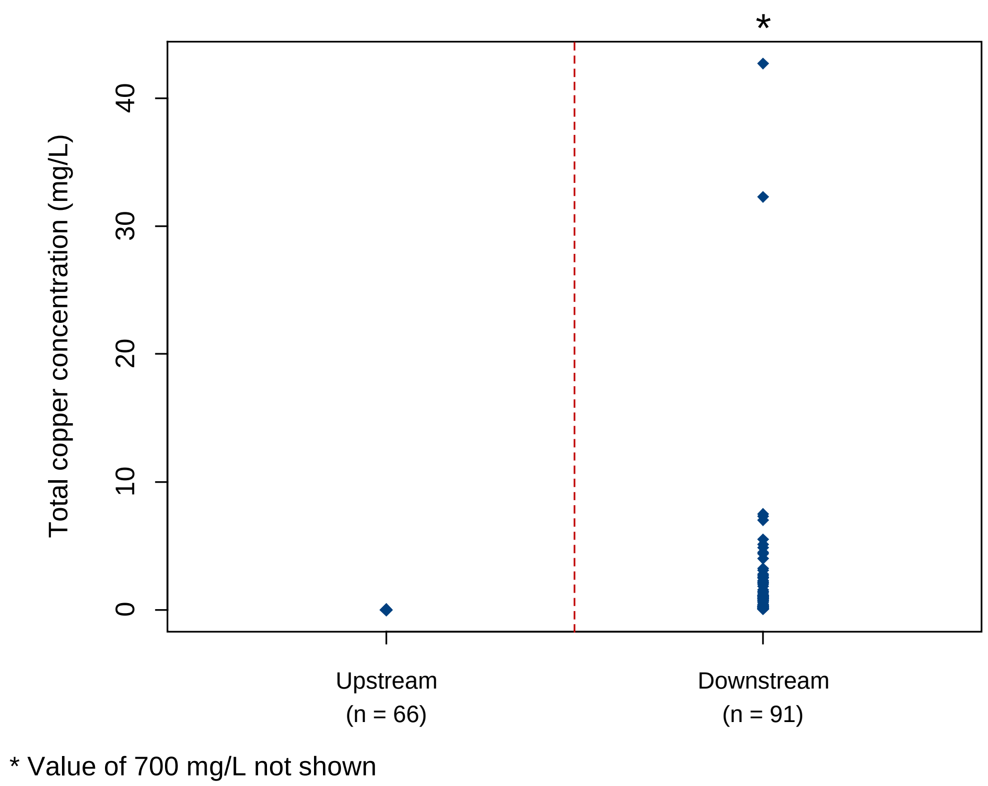

Figure 3.2. Surface water total copper concentrations in Mill Creek upstream and downstream of influence from the Rio Tinto Mine. Samples reported as nondetected are plotted at one-half the detection limit.

Source: RTWG, 2002.

Available data indicate that surface water in the East Fork Owyhee River downstream of the Mill Creek confluence has been exposed to hazardous substances released from the mine. Maximum total copper concentrations measured in the East Fork Owyhee River downstream of the Mill Creek confluence were up to 18 times greater than those measured upstream of the mine (Figure 3.3). Copper was detected in 75 out of 96 samples in the downstream reach, compared to 71 out of 136 samples from the upstream reach. The maximum detected copper concentration measured in the downstream East Fork Owyhee River reach was 0.9 mg/L, compared to 0.05 mg/L in the upstream reach.

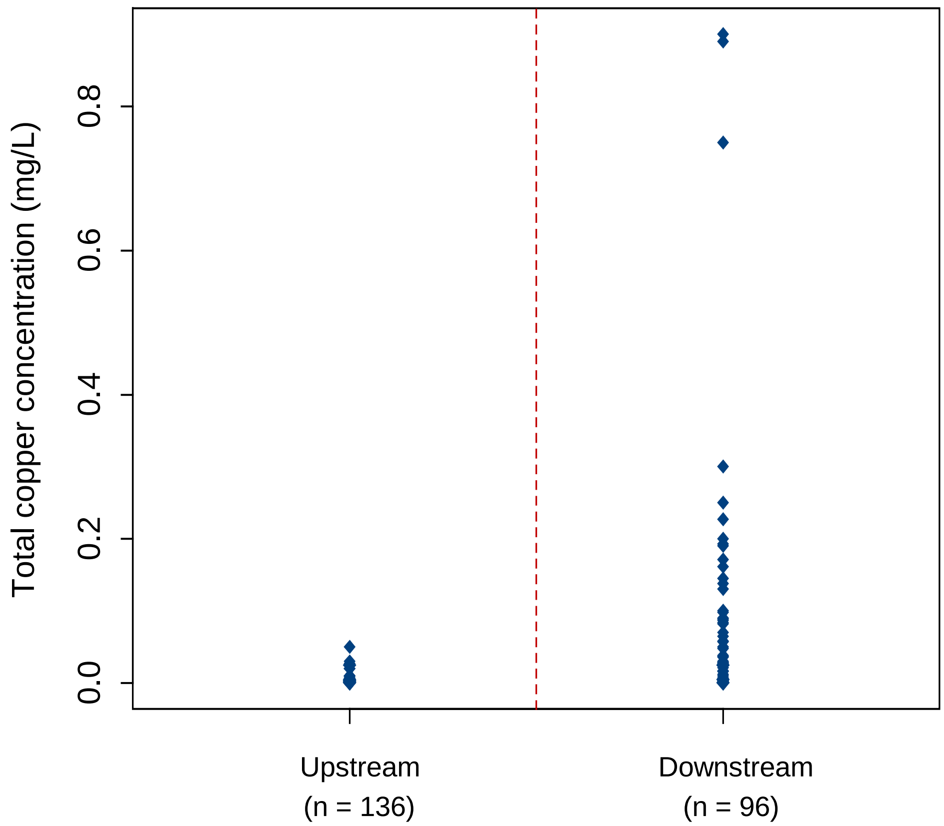

Figure 3.3. Surface water total copper concentrations in the East Fork Owyhee River upstream and downstream of influence from the Rio Tinto Mine. Samples reported as nondetected are plotted at one-half the detection limit.

Source: RTWG, 2002.

3.3 Sediment Resources

Sediments are defined in the DOI regulations as a component of the surface water resource [43 CFR § 11.14 (pp)]. However, for the purposes of this Assessment Plan, sediments are addressed separately from surface water because specific sediment data have been collected at this site, and sediments can be an ongoing exposure pathway to other natural resources.

Concentrations of copper and zinc in sediments collected from the drainages of Mill Creek and the East Fork of the Owyhee River are presented to confirm exposure of sediments to hazardous substances. Data from surface (grab) and subsurface samples are presented together to describe the general exposure of this resource to hazardous substances.

Available sediment data are limited in Mill Creek, with only two samples collected in the upstream reach and four in the downstream reach. However, copper and zinc concentrations in these samples provide evidence that sediment resources in Mill Creek have been exposed to hazardous substances released from the mine (Figures 3.4 and 3.5). The maximum detected copper concentration in sediment in the downstream reach was 540 ppm compared to a maximum concentration of 16 ppm in the upstream reach. Similarly, the maximum detected zinc concentration in sediment in the downstream reach was 200 ppm compared to a maximum concentration of 57 ppm in the upstream reach.

Comparatively more data are available to assess exposure of East Fork Owyhee River sediments to hazardous substances (10 samples from the East Fork Owyhee River upstream of influence from the Rio Tinto Mine, and 8 samples from downstream of the mine site). Both copper and zinc were detected in all samples. Sediment concentrations of copper in the East Fork Owyhee River were elevated in the downstream reach compared to concentrations in the upstream reach (Figure 3.6). The maximum detected copper concentration in sediment in the assessment reach was 750 ppm, which is considerably greater than the other assessment reach samples recorded. However, even if this data point is considered an outlier, and the second greatest copper concentration of 328 ppm is considered, this value is still highly elevated when compared to the maximum concentration in the upstream reach of 16.9 ppm.

Concentrations of zinc were also elevated in the East Fork Owyhee River downstream of the mine site compared to concentrations upstream (Figure 3.7). The maximum detected zinc concentration in sediment in the downstream reach was 190 ppm compared to a maximum concentration of 70.7 ppm in the upstream reach.

In summary, elevated metal concentrations have been measured in sediment downstream of the mine. Although the number of available sediment samples is limited, the existing data indicate that sediment resources have been exposed to hazardous substances released from the mine.

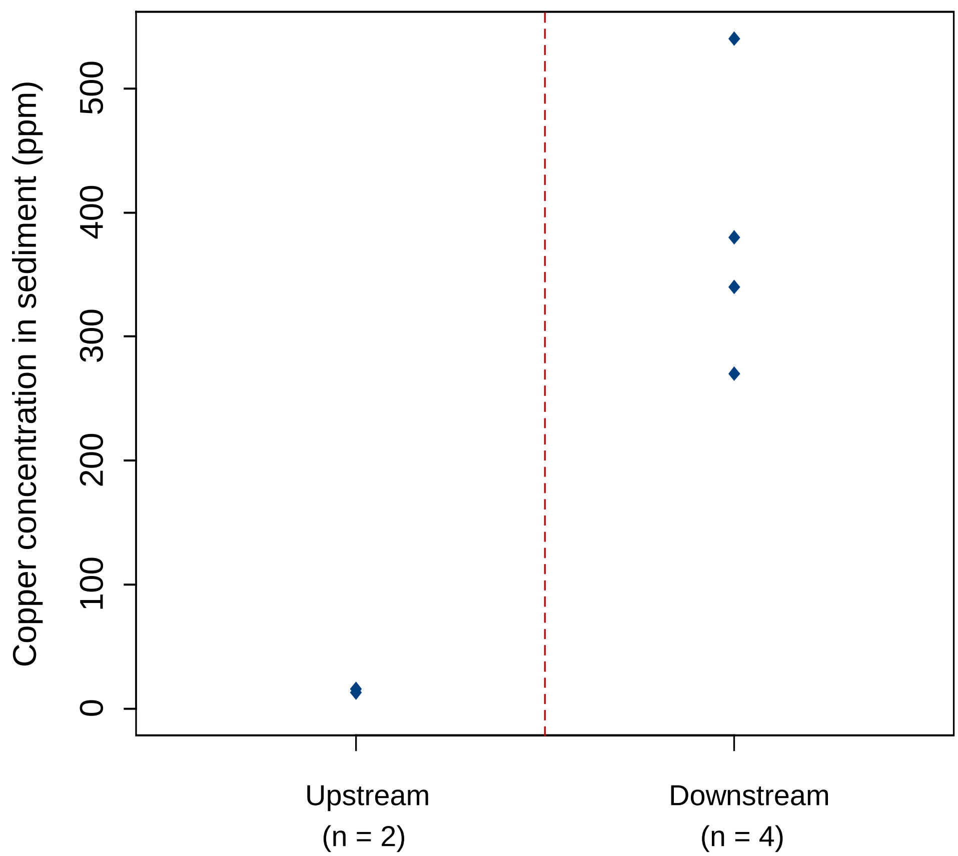

Figure 3.4. Sediment copper concentrations in Mill Creek upstream and downstream of influence from the Rio Tinto Mine.

Source: RTWG, 2002.

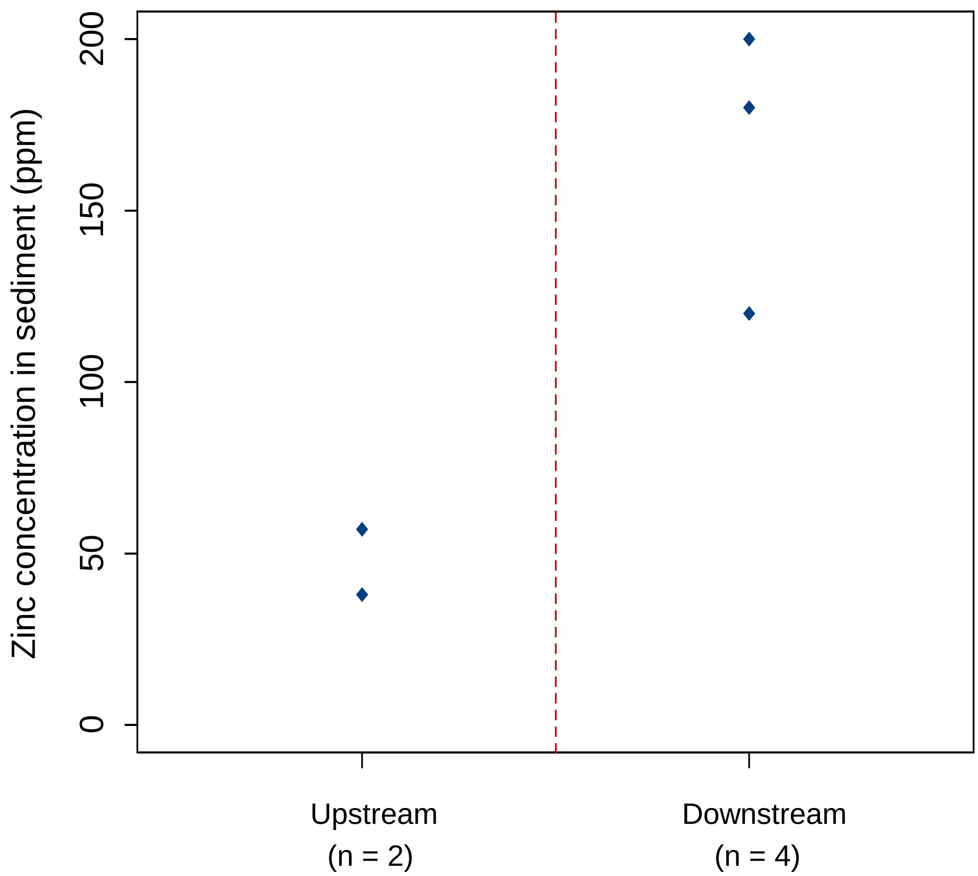

Figure 3.5. Sediment zinc concentrations in Mill Creek upstream and downstream of influence from the Rio Tinto Mine.

Source: RTWG, 2002.

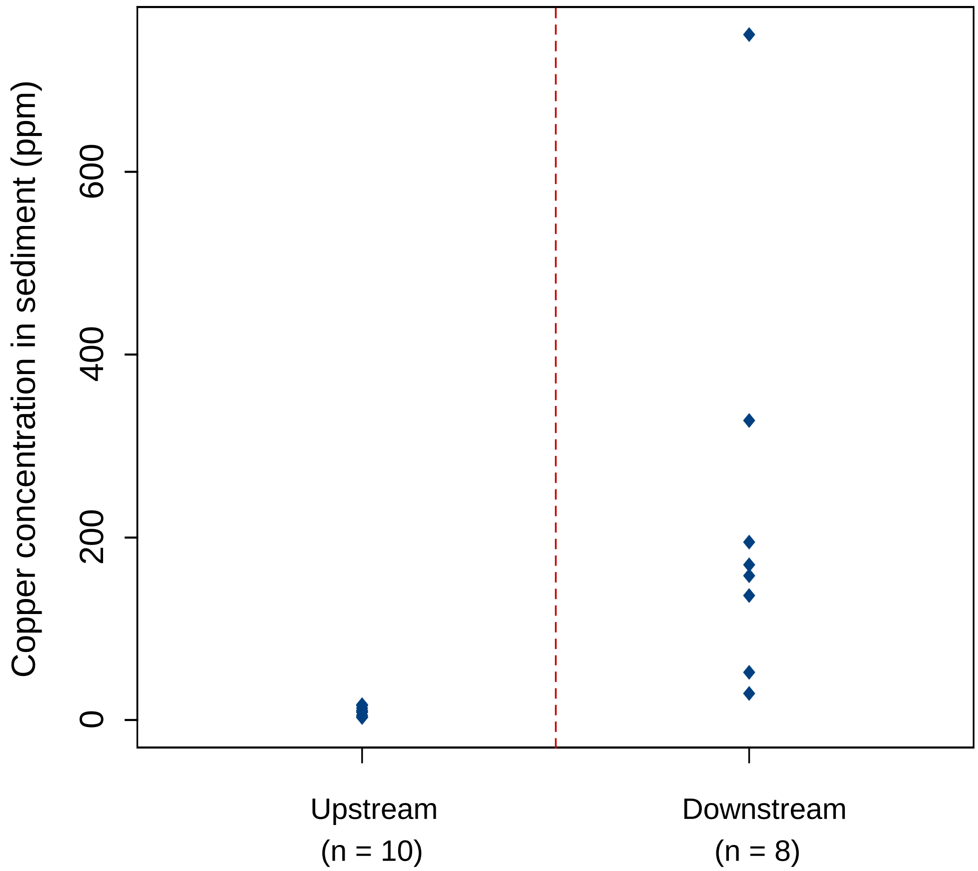

Figure 3.6. Sediment copper concentrations in the East Fork Owyhee River upstream and downstream of influence from the Rio Tinto Mine.

Source: RTWG, 2002.

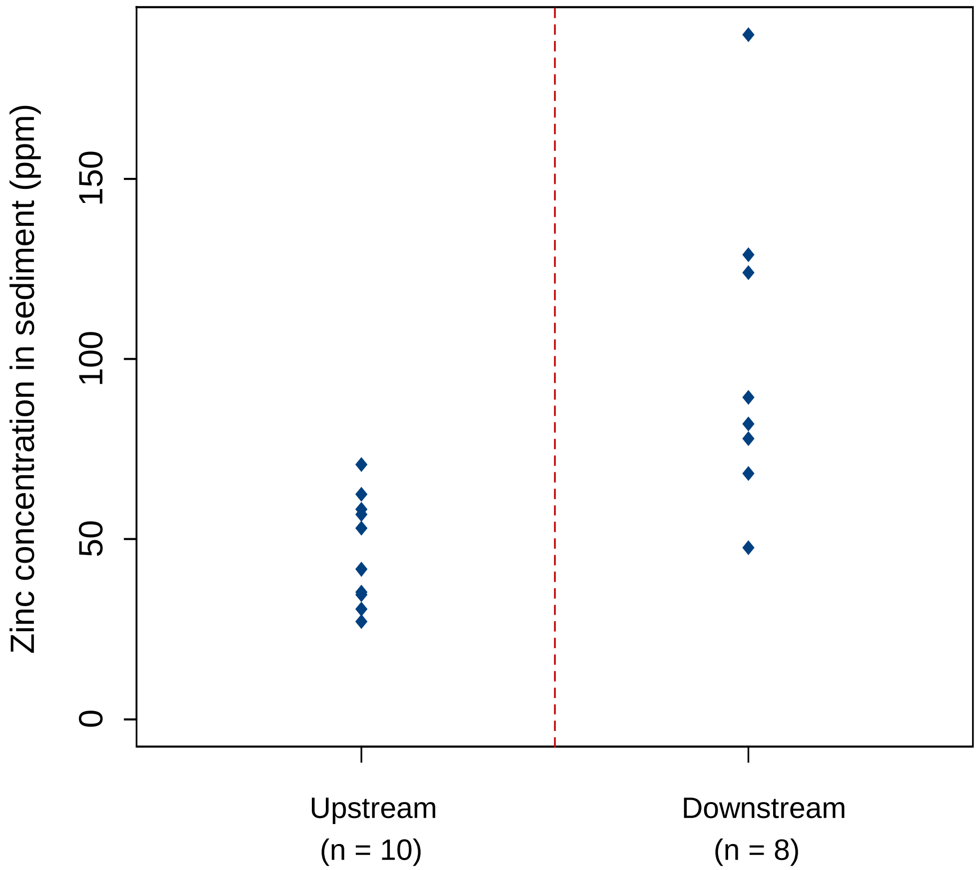

Figure 3.7. Sediment zinc concentrations in the East Fork Owyhee River upstream and downstream of influence from the Rio Tinto Mine.

Source: RTWG, 2002.

3.4 Conclusions

The available data confirm that natural resources have been exposed to hazardous substances released from the mine. Exposure of surface water and sediment to metals in Mill Creek downstream of the mine and on the East Fork of the Owyhee River downstream of the Mill Creek confluence is confirmed, and exposure of surface water to acidity is confirmed in Mill Creek.

While specific hazardous substances and exposure media are discussed here, this does not imply that other exposure media are not exposed or that media have not been exposed to additional hazardous substances.

4. Injury Assessment Approach

Chapter 3 presented data confirming that natural resources in the assessment area have been exposed to multiple hazardous substances, including but not limited to copper and zinc, as well as acidity. Natural resources, including surface water, sediments, groundwater, floodplain soils, riparian vegetation, aquatic biota, and terrestrial wildlife resources, may be injured as a result of this exposure. The Trustees will conduct an injury assessment to determine the nature and extent of injuries to these resources. Generally, the purpose of the injury assessment is to determine whether injuries to natural resources have occurred [43 CFR § 11.62], to identify the environmental pathways through which injured resources have been exposed to hazardous substances [43 CFR § 11.63], and to quantify the degree and extent (spatial and temporal) of injury in terms of a reduction of the quantity and quality of services from baseline conditions [43 CFR § 11.70].

DOI regulations define “injury” as a:

> measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a . . . release of a hazardous substance, or exposure to a product of reactions resulting from the . . . release of a hazardous substance. As used in this part, injury encompasses the phrases “injury,” “destruction,” or “loss” [43 CFR § 11.14(v)].

This chapter provides an overview of potential injuries to natural resources that will be assessed by the Trustees and describes the approaches that will be used to assess those injuries. Specifically, this chapter addresses the Trustees’ proposed approaches for injury determination and injury quantification. The proposed approach for identifying, selecting, and scaling appropriate restoration actions is described in Chapter 5.

Section 4.1 describes the overall approach to be taken in assessing injury. Sections 4.2 to 4.8 describe in more detail the specific approaches that will be used to determine and quantify injuries for different natural resources. Section 4.9 describes the approach for assessing the loss of tribal cultural services resulting from hazardous substance releases.

4.1 Injury Assessment Overall Approach

To assess injuries, the Trustees intend to follow the DOI regulations for conducting an NRDA at 43 CFR Part 11 (see Section 1.3 of this document).

4.1.1 Injury determination

The Trustees will determine whether an injury to one or more natural resources has occurred as a result of releases of hazardous substances [43 CFR § 11.62]. This determination will include the following two steps:

1. **Determination that injury has occurred.** In this first step, the Trustees will determine whether injuries that meet the definitions of injury in 43 CFR § 11.62 for surface water, sediment, groundwater, geologic, and biological resources have occurred. In addition, since assessment procedures set in 43 CFR Part 11 are not mandatory and the regulations do not forbid the use of other injury definitions [43 CFR § 11.10], the Trustees will consider other injuries not explicitly identified in the DOI regulations. For example, the Trustees will determine injuries via loss of natural resource services to the public and/or loss of unique natural resource services provided to the Shoshone-Paiute Tribes. Such loss of services may result from perception of contamination and changes in use resulting from releases of hazardous substances. Since loss of services provided by resources may be used to determine the amount of damages, if services are lost because of the release of hazardous substances that causes a "measurable adverse change . . . in the chemical or physical quality . . . of a natural resource" [43 CFR § 11.14 (v)], the resources can be considered injured.

2. **Pathway determination.** The Trustees will determine whether sufficient exposure pathways exist or have existed by which hazardous substances are transported in the environment and natural resources are exposed to those substances [43 CFR § 11.63]. Pathways will be determined using a combination of information about the nature and transport mechanisms of the hazardous substances, potential pathways, and data documenting the presence of the hazardous substance in the pathway resource.

4.1.2 Injury quantification

Quantification of injuries to natural resources will be conducted primarily to provide information that is relevant to quantifying damages. Quantification will include several key components:

1. **Characterization of baseline conditions.** The injuries determined by the Trustees will be quantified in terms of changes in natural resources and the services they provide from "baseline conditions" [43 CFR § 11.71(b)(2)]. Baseline refers to the conditions that would have existed had the releases of hazardous substances not occurred [43 CFR § 11.72 (b)(1)]. The DOI regulations suggest using historical data to evaluate baseline conditions, if they are available [43 CFR § 11.72 (c)]. Where historical data are not available, data from control areas may be used [43 CFR § 11.72 (d)]. No quantitative

baseline data collected at this site before the release have yet been identified, and thus the Trustees propose to use data from control areas to characterize baseline conditions and compare them to assessment area conditions. As the regulations indicate, control areas will be selected based on their similarity to the assessment area and lack of exposure to the release [43 CFR § 11.72 (d)(1)].

2. **Quantification of spatial and temporal extent.** The Trustees will evaluate contaminant data, historical records, and cultural use information to determine the spatial and temporal extent of injuries to natural resources. Tools such as geographic information systems (GIS) may be used to facilitate spatial quantification.

3. **Quantification of service losses.** Quantification will also involve determining the services that are normally produced by the natural resources, under baseline conditions, and evaluating how these services have been and will be disrupted by the release [43 CFR § 11.71 (b)].

4. **Estimation of recovery to baseline**. The Trustees will estimate the time needed for recovery of injured resources and the services they provide to baseline levels. This evaluation will include an estimate of recovery time if no actions beyond response actions are taken, and estimates of recovery time for possible alternatives for restoration, rehabilitation, replacement, and/or acquisition of equivalent resources [43 CFR § 11.73].

4.1.3 Data sources

The Trustees will emphasize the use of existing data in their injury assessment. However, available data for assessing injuries to some natural resources are limited. Thus, the Trustees propose to rely on a combination of existing data and targeted injury assessment studies. In this way, the Trustees will ensure that the NRDA process is efficient and cost-effective.

Existing data

The Trustees will review and compile historical and current site-specific baseline and assessment area data. The results of any ongoing monitoring programs will also be examined. Literature and document reviews will be conducted to develop injury thresholds against which environmental exposure data can be compared.

Additional studies

Existing information will be supplemented by targeted site-specific field and laboratory studies where necessary to determine and quantify injury. The additional studies described in this chapter were selected by the Trustees based on an evaluation of study objectives and level of priority. The studies will be designed to provide additional data that will be used in assessing injury, determining pathways, evaluating baseline conditions, and quantifying injuries to natural resources, and will be coordinated to provide information on the relationships of contaminants in associated natural resources. This Assessment Plan describes these data collection efforts in general terms only, and detailed sampling and analysis plans (SAPs) will be prepared at a later date, before initiation of any study.

4.1.4 Ecosystem-level evaluation

Consistent with the DOI regulations, injury determination and quantification will be evaluated resource by resource, as described in this chapter. However, natural resources and the ecological services they provide are interdependent. For example, surface water; bed, bank, and suspended sediments; floodplain soils; and riparian vegetation together provide habitat — and lateral and longitudinal connectivity between habitats — for aquatic biota, semi-aquatic biota, and upland biota dependent on access to the creeks in the area. Hence, injuries to individual natural resources may cause ecosystem-level service reductions. The Trustees will consider these interdependent ecosystem-level service losses when conducting their injury assessment.

4.2 Injury Assessment for Surface Water Resources

According to DOI NRDA regulations, surface water resources include surface water and suspended, bed, and bank sediments [43 CFR § 11.14 (pp)]. This section presents a summary of the approach the Trustees will use to assess injuries to surface water. Injury to suspended, bed, and bank sediments is discussed in Section 4.3. Injury to floodplain sediments, included in the category of geological resources, is discussed in Section 4.5.

4.2.1 Approach

Injury determination

Based on an initial review of existing data, the relevant DOI regulation definitions for the determination of injuries to surface water resources in the assessment area include the following:

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411-1416 of the SDWA, or by other federal or state laws or regulations that establish such standards for drinking water, in surface water that was potable before the release [43 CFR § 11.62(b)(1)(i)].

- Concentrations and duration of hazardous substances in excess of applicable water quality criteria established by Section 304(a)(1) of the CWA, or by other federal or state laws or regulations that establish such criteria, in surface water that before the release met the criteria and is committed use as habitat for aquatic life, water supply, or recreation [43 CFR § 11.62(b)(1)(iii)].

- Concentrations and duration of hazardous substances sufficient to have caused injury to groundwater, air, geologic, or biological resources, when exposed to surface water [43 CFR § 11.62(b)(1)(v)].

Each of these injury definitions consists of several components. Table 4.1 summarizes the components of each definition and the approaches that will be taken in assessing each component.

Table 4.1. Components of relevant surface water injury definitions

Injury definition	Definition components	Evaluation approach
Water quality criteria exceedences [43 CFR § 11.62(b)(1)(iii)]	Surface waters are a committed use as aquatic life habitat, water supply, or recreation.	Determine whether assessment area water bodies have or had committed uses.
	Concentrations and duration of hazardous substances are in excess of applicable water quality criteria.	Perform temporal and spatial comparisons of surface water concentrations to state, tribal, and federal water quality criteria/standards.
	Criteria were not exceeded before release.	Compare conditions before the release (or a surrogate) to state, tribal, and federal water quality criteria.
Drinking water standards exceedences [43 CFR § 11.62 (b)(1)(i)]	Concentrations and duration of hazardous substances are in excess of applicable drinking water standards.	Perform temporal and spatial comparisons of surface water concentrations to state, tribal, and federal standards.
	Water was potable before release.	Compare conditions before the release (or a surrogate) to drinking water standards.
Biological resources injured when exposed to surface water [43 CFR § 11.62(b)(1)(v)]	Biological resources are injured when exposed to surface water.	Determine whether natural resources have been injured as a result of exposure to surface water.

The Trustees will compile, review, and evaluate information relevant to evaluating injury to surface water resources, including surface water chemistry data; flow information; designated and committed uses; irrigation uses; and any other Tribal cultural uses. This information will be used to compare surface water conditions to the injury definitions.

In determining injuries, the Trustees will first review designated uses of surface water, then compare data on concentrations of hazardous substances in surface water to applicable standards. The Trustees propose to use standards and criteria promulgated by the federal government, the State of Nevada, and the State of Idaho to assess injuries to surface water, such as aquatic life criteria, criteria for irrigation and watering of livestock, criteria for the protection of human health, and drinking water standards. Standards that apply to one state will not be used to evaluate injury in another state. When multiple relevant standards or criteria are available for a given use of surface water, such as providing habitat for aquatic biota and irrigation, the Trustees will use the most stringent applicable standard or criterion to determine injury to surface water.

In addition, standards currently under review, such as the EPA's core Federal Water Quality Standards for Indian Country Waters (U.S. EPA, 2001) or standards submitted by the Shoshone-Paiute Tribes, may also be used.

Surface water resources may also be injured because other natural resources may have been injured as a result of exposure to contaminated surface water. For example, as described in Section 4.6, fish and benthic invertebrates may be injured due to exposure to a contaminated surface water pathway. Thus the surface water resource may be injured because its ability to provide a habitat service is impaired.

Aquatic life criteria

The Trustees will rely on federal and state water quality criteria designated to protect aquatic life (generally referred to as aquatic life criteria, or ALC). Pursuant to Section 304 of the CWA, the EPA establishes national recommended ambient water quality criteria that are generally applicable to the water of the United States (U.S. EPA, 2002a). Similar water quality criteria have been established by the State of Nevada (2003) and the State of Idaho (2003) in their administrative codes.

ALC include acute and chronic limits for numerous metals and other surface water pollutants. The acute criterion (the criterion maximum concentration, or CMC) is an estimate of the highest concentration of a substance in surface water to which an aquatic community can be exposed briefly without an unacceptable effect. The chronic criterion (the criterion continuous concentration, or CCC) is an estimate of the highest concentration of a substance in surface water to which an aquatic community can be exposed indefinitely without an unacceptable effect (63 Federal Register 68364, December 10, 1998).

The acute and chronic criteria are each one of three components that constitute an ALC (U.S. EPA, 1987). The other two parts are the averaging period and the frequency of allowable exceedence. For arsenic, cadmium, copper, nickel, and zinc, the acute averaging period is 1 hour, the chronic averaging period is 4 days, and the frequency of allowable exceedence for both chronic and acute criteria is no more than once every 3 years.

The toxicity of some metals to aquatic species varies with water hardness. Water hardness is typically measured as the amount of calcium plus magnesium present and is expressed as equivalent milligrams of calcium carbonate per liter. Metals such as cadmium, copper, lead, nickel, silver, and zinc are more toxic at low hardness values than at high hardness values. The EPA and state ALC values include equations to calculate freshwater dissolved metals criteria in µg/L, based on a hardness value in mg/L.

The Trustees will rely on appropriate EPA guidance in the application of ALC. For example, the EPA recommends the use of dissolved metal concentrations for establishing compliance with ALC (58 FR 32131, June 8, 1993). However, the EPA aluminum and selenium criteria and the State of Nevada criteria for iron and mercury are based on total recoverable metals (U.S. EPA, 2002a; State of Nevada, 2003).

Ambient water quality criteria for irrigation and watering of livestock

The U.S. government has not established national standards for contaminant concentrations in water used for livestock watering, and few national standards for irrigation. However, the State of Nevada (2003) has developed livestock watering guidelines and irrigation guidelines for several hazardous substances, and these guidelines will be used to assess injury to surface water that is used for irrigation.

Criteria for protection of human health

Pursuant to Section 304 of the CWA, the EPA establishes national recommended ambient water quality criteria that are generally applicable to the waters of the United States. These water quality criteria are intended to ensure that fish do not accumulate concentrations of substances from the water that would adversely affect the health of humans who ingest the fish. The State of Idaho has also designated criteria for protection of humans who consume aquatic organisms.

EPA is reassessing the federal water quality criterion for arsenic for the protection of humans who consume aquatic organisms, but the reassessment is not yet complete (U.S. EPA, 2002a). The current value is based on a relatively high bioconcentration factor for oysters that has been reported in the literature (U.S. EPA, 2002b), and available evidence indicates that fish accumulate arsenic from water at much lower levels than that used to derive the criterion (Eisler, 1988). The Trustees may elect to use the reassessed standard when it is developed.

Drinking water standards

To control the level of contaminants in the nation's drinking water, the EPA established three kinds of drinking water standards based on total recoverable metals. The Maximum Contaminant Levels (MCLs) are the highest level of a contaminant that is allowed in drinking water. The MCL Goals (MCLGs) are nonenforceable health goals that are set at levels at which no known or anticipated adverse effects on human health occur and which allow an adequate margin of safety. The Secondary Drinking Water Regulations (SDWRs) are also nonenforceable federal guidelines regarding cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) of drinking water. The Trustees propose using MCLs and SDWRs to assess injuries to drinking water services.

The states of Nevada and Idaho also have established standards to protect human health for municipal or domestic water supply use, which the Trustees will also use to assess injuries to surface water.

Although the EPA approved a new MCL for arsenic of 10 μg/L in 2001, this standard will not go into effect until January 2006 (66 FR 6976, January 22, 2001). The Trustees will use the most time-appropriate MCL for arsenic (and other hazardous substances, as appropriate) for assess injuries in different time periods.

Injury quantification

Quantification of injuries to surface water resources will include an evaluation of the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries throughout the assessment area. Injury quantification will be based primarily on exceedences of criteria and standards, on quantification of injury to other resources injured by exposure to surface water, and on the loss of services resulting from these injuries (see Section 4.9).

Methods to quantify injuries may include the use of GIS and dilution models. The temporal extent of injuries will be quantified through examination of available historical surface water metal concentration data and other site records. Impacted water bodies may be divided into sections (e.g., Mill Creek, and the East Fork Owyhee River) for quantification of injuries. Such divisions would be motivated by a recognition that the degree and duration of injury may vary spatially.

Pathway determination

Pathways to surface water may include direct discharges of hazardous substances to surface water, or indirect pathways via discharges of hazardous substances to soil, groundwater, and sediment (Figure 4.1). Processes such as soil transport, groundwater transport and interaction

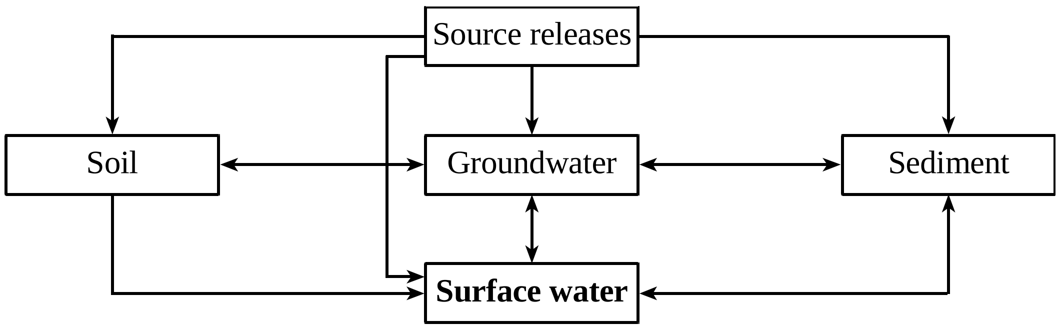

Figure 4.1. Potential surface water exposure pathways.

with surface water, and sediment transport are potential pathways for hazardous substances to move from the source of the release to surface waters in the assessment area.

The Trustees will rely on existing data and results of additional injury studies to demonstrate whether hazardous substances are present in "sufficient concentrations" in pathway resources [43 CFR § 11.63 (a)(2)]. Data will be used to evaluate the loading and downstream movement of hazardous substances through pathway resources into surface water. These results, combined with an evaluation of the mobility of the hazardous substances and other information on water management practices in the assessment area, will be used to determine the exposure pathways and extent of exposure.

4.2.2 Available data

Several sources of surface water data are available. Sources include historical and ongoing water quality data and instantaneous flow measurements collected by the PRPs,[1] and by state, federal, and Tribal trustees and other agencies. In addition, continuous hydrological data have been collected by the USGS. The majority of the water quality data have been compiled by the RTWG into a site database (RTWG, 2002), which will be used in the assessment of surface water injury.

Before assessing injuries to surface water, the Trustees will evaluate the available data sources for their usability and applicability to the surface water injury assessment. Documentation regarding data collection methods and data quality assurance and control varies. Most of the older data are not accompanied by supporting QA/QC information, and database quality assurance procedures by MWH are unknown. Major data sources are described below.

1. Data collected by the PRPs includes data collected by the Rio Tinto Working Group, as well as data collected by PRPs before the formation of the group (e.g., Cliffs Copper Corporation).

Rio Tinto Working Group

The Rio Tinto Working Group has collected surface water samples from many locations at the mine site, in Mill Creek, and in the East Fork Owyhee River since 1995 (RTWG & MWH, 2002a, 2002b). Sampling was conducted quarterly until October 2000, and monthly since then. Sampling locations include both routine and opportunistic monitoring sites, and data include both total and dissolved fractions of a selected set of metals as well as other parameters such as pH and hardness. Discharge was recorded in conjunction with many water quality samples and on additional dates when only field observations were made.

Cliffs Copper Corporation

Samples were collected by Cliffs Copper Corporation in the early 1970s from the mine water treatment plant and in Mill Creek and the East Fork Owyhee River. Records for these samples contain information on only a select set of total metals and trace elements, pH, and flow. Locations have been assigned based on descriptions of sample locations. These data have been described in reports by RTWG & MWH (2002a, 2002b).

NDEP

The NDEP has collected water quality samples in the East Fork Owyhee River watershed since 1966 (RTWG & MWH, 2002a, 2002b). Early on, sampling was conducted only once or twice a year, but since 1996, samples have generally been collected three times a year. NDEP has also maintained a routine monitoring station on Mill Creek since March 1997, where water quality samples are also collected three times a year. In addition, sampling has been conducted by the NDEP during several site inspections (May 1980, December 1984, June/July 1985, April 1993, and July 1996). Data since approximately 1998 were analyzed for both dissolved and total fractions of metals and trace elements.

NDOW

The NDOW collected surface water samples in the early 1970s from Mill Creek and the East Fork Owyhee River (RTWG & MWH, 2002a, 2002b). These samples were analyzed for selected constituents, and metals were analyzed only as total metals. In 1997, 2000, and 2001, NDOW sampled near the mine site and in Mill Creek and the East Fork Owyhee River for field parameters such as pH and temperature, but not for fractions of metals and trace elements.

EPA

The EPA and/or their consultant Ecology and Environment (E&E) collected surface water samples from several locations at the mine site and in Mill Creek during site inspections in 1972, 1988, and 2000 (RTWG & MWH, 2002a, 2002b). Early samples were analyzed for only a selected set of total metals and trace elements, and the 2000 samples were analyzed for both dissolved and total metals, trace elements, and general water quality parameters.

USFS

The USFS collected surface water samples from the mine site, Mill Creek and the East Fork Owyhee River on three occasions in 1970, 1989, and 1988 (RTWG & MWH, 2002a, 2002b). Samples were analyzed for a selected subset of total metals, trace elements, and general water quality parameters.

Tribes

In 1996, the Tribes sampled 10 downstream locations on the East Fork Owyhee River as part of the Duck Valley Reservation Water Quality Investigation (RTWG & MWH, 2002a). These samples were analyzed for both total and dissolved metals and general water quality parameters.

In August 1999, several surface water samples were collected on behalf of the Shoshone-Paiute Tribes from Mill Creek upstream of the mine, at a seep at the base of the tailings ponds, and at several locations in the East Fork Owyhee River (Shoshone-Paiute Tribes of Duck Valley, 2000). These samples were analyzed for total metals and trace elements, and two samples were analyzed for dissolved metals and trace elements.

In 2002, the Shoshone-Paiute Tribes conducted a sampling in conjunction with the EPA, which included surface water sampling at 10 sites in the East Fork of the Owyhee River and in reservoirs recharged by the river (Shoshone-Paiute Tribes of Duck Valley, 2000). Samples for dissolved metals and trace elements were exposed to nitric acid before filtration and thus were determined to be unsuitable for screening purposes. Thus this study contains results only for total metals, trace elements, and field parameters (pH, conductivity, and DO).

USGS

The USGS monitors flow at two gaging stations on the East Fork Owyhee River (Figure 4.2). Daily flow at station 13174500 (East Fork Owyhee River near Gold Creek, NV) is available from 1916 to the present, and daily flow at station 13175100 (East Fork Owyhee River near Mountain City, NV) is available from 1991 to the present. Another station on the East Fork Owyhee River near Owyhee (13176000; East Fork Owyhee River above China Dam near Mountain City, Nevada) recorded daily flow from 1939 to 1985, but is no longer active. The USGS datasets also include some measurements of temperature and conductivity, but no chemical analyses. These USGS data can be downloaded from the website http://waterdata.usgs.gov/nwis/sw.

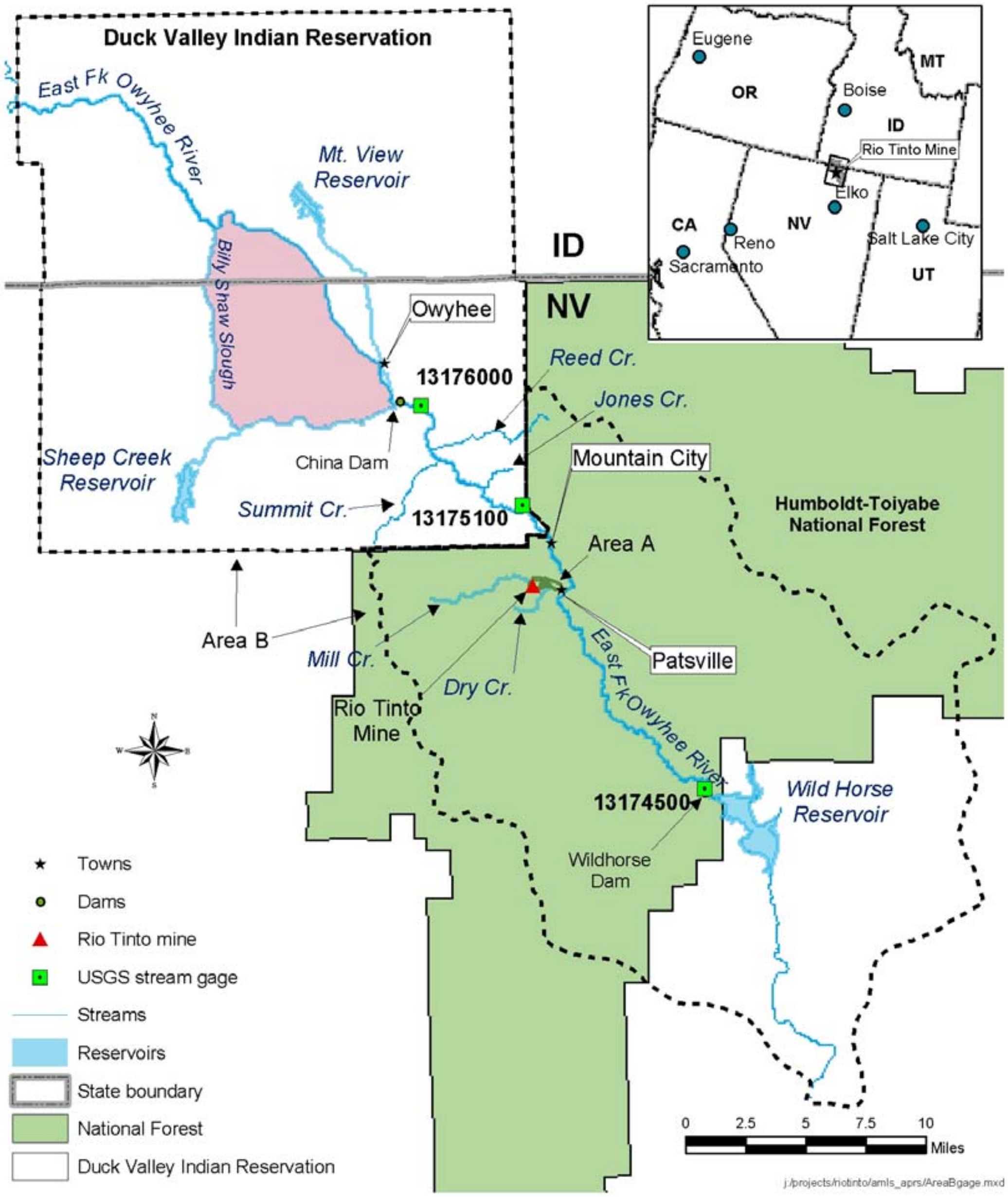

Figure 4.2. USGS gaging stations on the East Fork Owyhee River.

The USGS collected surface water data from the mine site, Rio Tinto Gulch, and Mill Creek during a site investigation in June 1999. These samples were analyzed for total metals and trace element concentrations and general water quality parameters (RTWG & MWH, 2002b). Additionally, samples in the East Fork Owyhee River reference area were collected by USGS as part of a larger sampling program in northern Nevada and southern Idaho in 1979 and 1980 (USGS, 1999). These samples were analyzed for total metals, trace elements, and general water quality parameters (RTWG & MWH, 2002a).

4.2.3 Additional studies

To supplement the available surface water data, the Trustees will conduct a surface water quality study in Mill Creek and the East Fork Owyhee River. Sampling will include the collection of surface water samples for laboratory analysis of dissolved and total constituents and field measurements of parameters such as pH and streamflow. Samples will be analyzed for metal concentrations as well as other parameters that can influence metal toxicity, such as calcium, magnesium, and dissolved organic carbon concentrations. This study will be coordinated with other related studies such as sediment sampling (Section 4.3.3) and invertebrate sampling (Section 4.6.3).

Potential sampling locations for the surface water study include Mill Creek upstream and downstream of the mine; the East Fork Owyhee River upstream, at, and downstream of the Mill Creek confluence; the East Fork Owyhee River throughout the DVIR; and irrigation canals and reservoirs along the East Fork Owyhee River. It is anticipated that samples will be collected at up to approximately 15-20 locations.

The surface water study will include the following components:

- *Early snowmelt sampling* to characterize releases of hazardous substances into Mill Creek and the East Fork Owyhee River at this time of year. Available data indicate that high metal loadings from the mine into Mill Creek occur during this period, and additional sampling is needed to more fully characterize these loadings, including timing, magnitude, geochemistry, resulting concentrations, and downstream extent of exposure. The sampling will include synoptic sampling (i.e., sampling conducted at multiple locations simultaneously) to characterize the downstream extent of exposure.

- *Baseflow sampling* in late summer/early fall to characterize the nature and downstream extent of exposure from releases of hazardous substances into Mill Creek and the East Fork Owyhee River during this hydrologic period.

- *Stormflow sampling* (if possible) will include sampling during or just after rainstorms at the mine site. Available data indicate that there may be elevated releases of metals and trace elements during these periods.

The data collected from this study will be used to (1) define the temporal and downstream extent of surface water exposure to mine-released substances, (2) determine the downstream extent of exceedences of applicable water quality standards, and (3) evaluate the potential that releases from the mine site are causing adverse toxicological effects to aquatic biota at different locations in Mill Creek and the East Fork Owyhee River.

4.3 Injury Assessment for Sediment Resources

Sediment resources are defined by DOI NRDA regulations as a component of surface water resources as described in Section 4.2 [43 CFR § 11.14 (pp)]. Injury assessment activities for sediment are described separately here because of differences in relevant injury definitions, data availability, and additional studies between sediment and other surface water resources.

4.3.1 Approach

Injury determination

Based on initial review of existing data, the relevant NRDA regulatory definitions for the evaluation of injuries to sediment resources include the following:

- Concentrations and duration of hazardous substances sufficient to cause injury to biological resources, ground water, or surface water resources that are exposed to sediments [43 CFR § 11.62(b)(v); 11.62(e)(11)].

This injury definition will be evaluated using a combination of approaches. Table 4.2 summarizes the components of the definition and the approaches that the Trustees intend to use to determine injuries to sediment.

The Trustees will compile, review, and evaluate existing information relevant to assessing injury to sediment resources, including sediment chemistry data, benthic community data, and any relevant Tribal cultural uses.

Unlike for surface water, EPA has not developed relevant criteria to protect aquatic biota or wildlife from contaminants in sediments. However, injury to sediments may be demonstrated if concentrations in the sediments are sufficient to cause injury to other resources. In determining injuries to sediment resources, the Trustees will compare data on concentrations of hazardous

Table 4.2. Components of relevant sediment injury definitions

Injury definition	Definition components	Evaluation approach
Biological resources injured when exposed to sediments [43 CFR § 11.62(b)(v); 11.62(e)(11)]	Biological resources are injured when exposed to sediments.	Compare sediment concentrations to consensus probable effect concentrations (PECs) and consensus threshold effect concentrations (TECs).
		Determine whether sediment concentrations have caused an adverse change in benthic invertebrate communities.

substances in sediment to numeric thresholds indicative of injuries to benthic invertebrates and will determine injuries to sediment via injuries to benthic invertebrates.

Sediment effect concentrations

Various federal, state, and provincial agencies in North America have developed numerical sediment quality guidelines, and sediment toxicity texts using a variety of approaches have been conducted to assess the quality of freshwater and marine sediments. The approaches that have been selected by individual jurisdictions differ based on the ecological receptors considered, the degree of protection afforded, the geographic area to which the values are intended to apply, and the intended uses of the values. MacDonald et al. (2000) assembled previously published sediment quality guidelines for 28 chemical substances and classified them into two categories according to their original narrative intent: a TEC and a PEC (MacDonald et al., 2000). TECs are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms are not expected to occur. TECs include threshold effect levels, effect range low values, lowest effect levels, minimal effect thresholds, and sediment quality advisory levels. PECs are intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are expected to occur frequently. PECs include probable effect levels, effect range median values, severe effect levels, and toxic effect thresholds. These previously published sediment quality guidelines were then used to develop two consensus-based sediment quality guidelines for each contaminant, a TEC and a PEC. MacDonald et al. (2000) evaluated the predictive ability of the consensus PEC numbers using 347 samples for cadmium, copper, nickel, and zinc and 150 samples for arsenic from freshwater systems in the United States. The consensus PEC numbers for arsenic, cadmium, copper, nickel, and zinc correctly predicted sediment toxicity in 76.9%, 93.7%, 91.8%, 90.6%, and 90%, respectively, of the samples.

Benthic invertebrate community evaluation

The Trustees will also evaluate effects on benthic macroinvertebrate communities that are indicative of injury, such as changes in community composition. Methods to determine injuries to benthic invertebrates are discussed in more detail in Section 4.6, injuries to aquatic biota.

Injury quantification

Quantification of injuries to sediment resources will include an evaluation of the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries throughout the assessment area. Sediment quality information will be used to assess spatial extent of injury and degree of injury. If available, sediment core information may be useful in interpreting the temporal (past) extent of injury.

Pathway determination

Pathways to sediment may include direct discharges of hazardous substances to sediment, and indirect pathways via discharges to surface water, soil, and groundwater (Figure 4.3). Processes such as natural soil erosion into streams, mass wasting of tailings and waste piles, surface water transport and deposition of sediment, and groundwater interaction with sediments and surface water are potential mechanisms for hazardous substances to move from the source of the release to sediments in the assessment area.

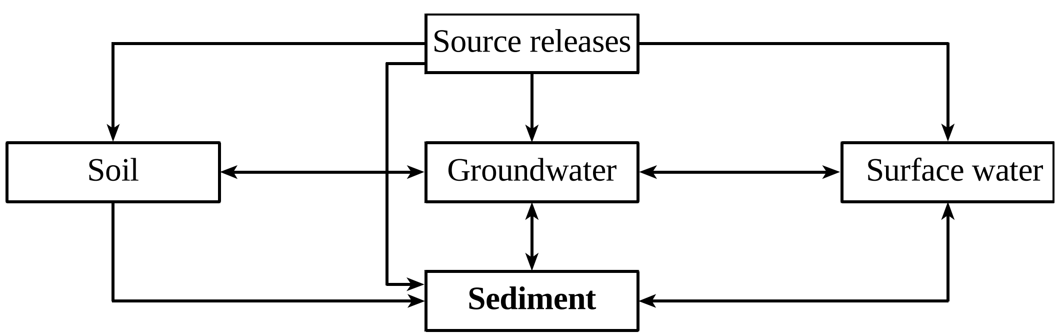

Figure 4.3. Potential sediment exposure pathways.

The Trustees will rely on existing data and results of additional injury studies to demonstrate whether hazardous substances are present in “sufficient concentrations” in pathway resources [43 CFR § 11.63 (a)(2)]. Data will be used to determine whether surface water and other potential pathway resources downstream of the site have been exposed to hazardous substances. These results, combined with an evaluation of the mobility of the hazardous substances and other information on water management practices in the assessment area, will be used to determine the exposure pathways and extent of exposure.

4.3.2 Available data

Several sources of sediment data are available. Sediment data have been collected by PRPs and by federal and Tribal trustees. Most sediment data are from the East Fork Owyhee River, and only a few samples have been collected from Mill Creek. The majority of the sediment data have been compiled by the RTWG into a site database, which will be used in the assessment of injury. Major data sources are described below.

Rio Tinto Working Group

RTWG conducted a sediment characterization study in 2002. Samples were collected from nine locations in the East Fork Owyhee River, from upstream of Mill Creek to the DVIR boundary. Three to four samples were collected at each location from depositional zones on both sides of the wetted perimeter and analyzed for total metals and trace element concentrations, physical parameters, and simultaneously extracted metals (SEM; RTWG & MWH, 2003a).

Tribes

In 1999, the Tribes collected sediment data from four locations in the East Fork Owyhee River as part of the Rio Tinto Mine/Mill Reclamation Audit (Shoshone-Paiute Tribes of Duck Valley, 2000). Sample locations were upstream of Mill Creek, downstream of Mill Creek (two locations), and just inside the reservation boundary. Sediment was collected from the surface (0-2 inches or 0-4 inches) at each of the four sampling locations, and an additional sample from a humic layer at 8-10 inches was collected from one of the locations downstream of Mill Creek. Samples were analyzed for total metals and trace elements.

In August 2002, the Tribes collected sediment samples in conjunction with the EPA as part of a prescreening level sampling investigation (Shoshone-Paiute Tribes of Duck Valley, 2004). Sediment cores were collected at nine locations on the East Fork Owyhee River from upstream of Mill Creek near the Rizzi Ranch to China Dam, and from two reservoirs on the DVIR, Sheep Creek Reservoir and Mountain View Reservoir. Cores were collected and split into upper and lower horizons and analyzed for total metals and trace elements.

EPA

On behalf of EPA, E&E collected grab sediment samples as part of a site inspection in 2000 (RTWG & MWH, 2002a). These samples were collected from the East Fork Owyhee River from upstream of Mill Creek to the DVIR boundary, and in Mill Creek both upstream and downstream of the mine. These samples were analyzed for total metals and trace elements.

Other sources

The USFWS collected two sediment samples from Sheep Creek and Mountain View Reservoirs in 1991 (Mullins et al., 1993; RTWG & MWH, 2002a). One composite sample was collected near the inflow to each reservoir from the 6-8 inch depth interval and analyzed for total metals and trace elements. The USGS collected sediment samples from the East Fork Owyhee River and Mill Creek in 1979 and 1980 as part of a regional sampling effort (USGS, 1999; RTWG & MWH, 2002a). Samples were analyzed for selected total metals (aluminum, iron, manganese, and vanadium), uranium, and rare earth elements.

4.3.3 Additional studies

To supplement the available sediment data, the Trustees will conduct a sediment study to collect and analyze sediments from selected locations along Mill Creek and the East Fork Owyhee River. Samples will be analyzed for metals, trace elements, and organic carbon. This study will be coordinated with other related studies such as surface water sampling (Section 4.2.3) and invertebrate sampling (Section 4.6.3).

Potential sampling locations for the surface water study include Mill Creek upstream and downstream of the mine; the East Fork Owyhee River upstream, at, and downstream of the Mill Creek confluence; the East Fork Owyhee River throughout the DVIR; and in depositional areas, irrigation canals, and reservoirs along the East Fork Owyhee River. Samples may include both surface grab samples and sediment cores, where appropriate. It is anticipated that sediment samples will be collected at up to approximately 20 locations.

The data collected from this study will be used to (1) define the temporal and downstream extent of sediment exposure to mine-released substances, and (2) evaluate the potential that releases from the mine site are causing adverse toxicological effects to benthic invertebrates at different locations in Mill Creek and the East Fork Owyhee River.

4.4 Injury Assessment for Groundwater Resources

According to DOI NRDA regulations, groundwater resources include water beneath the surface of land or water and the rocks or sediment through which it moves, and include any groundwater resources that meet the definition of drinking water supplies [43 CFR § 11.14 (t)], which are any raw or finished water sources that may be used by the public or by one or more individuals [43 CFR § 11.14 (o)].

4.4.1 Approach

Injury determination

Based on initial review of existing data, the relevant NRDA regulatory definitions for the evaluation of injuries to groundwater resources include the following:

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411-1416 of the SDWA, or by other federal or state laws or regulations that establish such standards for drinking water, in groundwater that was potable before the release [43 CFR § 11.62(c)(1)(i)].

- Concentrations and duration of hazardous substances sufficient to have caused injury to surface water, when exposed to groundwater [43 CFR § 11.62(c)(1)(iv)].

These injury definitions consist of several components. Table 4.3 summarizes the components of each definition and the approaches that may be taken in assessing each component.

Table 4.3. Components of relevant groundwater injury definitions

Injury definition	Definition components	Evaluation approach
Drinking water standards exceedences [43 CFR § 11.62 (c)(1)(i)]	Concentrations and duration of hazardous substances are in excess of applicable drinking water standards.	Perform temporal and spatial comparisons of surface water concentrations to state, tribal, and federal standards.
	Water was potable before release.	Compare conditions before the release (or a surrogate) to drinking water standards.
Other resources injured when exposed to groundwater [43 CFR § 11.62(c)(1)(iv)]	Surface water resources are injured when exposed to groundwater.	Determine whether surface water has been injured as a result of exposure to groundwater.

The Trustees will compile, review, and evaluate existing information relevant to evaluating injury to groundwater resources, including groundwater chemistry data; groundwater flow information; drinking water well data (location, depth, uses); irrigation uses; and any Tribal cultural uses.

In determining injuries to groundwater resources, the Trustees will compare data on concentrations of hazardous substances in groundwater to applicable standards. The drinking water standards that are described for surface water (Section 4.2.1) also apply to groundwater resources and the Trustees will use a similar approach in evaluating injuries to groundwater. Total metals and trace element concentrations will be used to compare to drinking water standards, and dissolved concentrations will be used when total concentrations are not available.

Groundwater resources may also be injured because other natural resources may have been injured as a result of exposure to contaminated groundwater. For example, if surface water is injured by exposure to a contaminated groundwater pathway, then the groundwater resource is also injured. The Trustees may evaluate injury to groundwater by considering whether concentrations of hazardous substances in groundwater are sufficient to cause injuries to surface water via water quality criteria exceedences, where it can be demonstrated that groundwater is an exposure pathway for surface water. For example, samples collected from any seeps or springs flowing from groundwater to surface water may be used to evaluate injury to groundwater under this definition.

Injury quantification

Quantification of injuries to groundwater resources will include an evaluation of the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries throughout the assessment area. Injury quantification will be based primarily on exceedences of criteria and standards, and information on use and on service losses resulting from the release of hazardous substances from the mine. The latter may require additional interview and survey work to assess whether human uses have changed as a result of releases of hazardous substances from the mine, and to what degree uses have changed. GIS may be used to facilitate spatial quantification.

Pathway determination

Pathways to groundwater may include direct discharges of hazardous substances to groundwater (in mine workings) or indirect pathways via discharges of hazardous substances to soil, surface water and sediment (Figure 4.4). For example, infiltration of rain and snowmelt through tailings piles, rising of capillary groundwater to sources of contamination in the unsaturated zone, or recharge of aquifers from streams may move hazardous substances into groundwater.

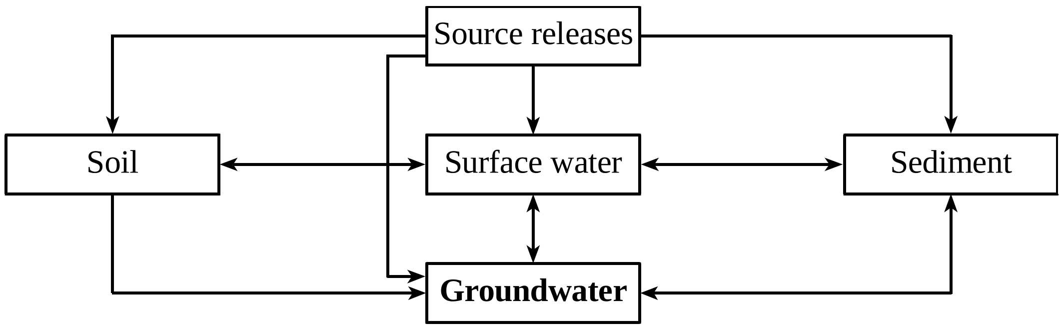

Figure 4.4. Potential groundwater exposure pathways.

4.4.2 Available data

Available data on groundwater are limited in terms of spatial extent and analytical parameters. The known sources are described below.

RTWG

The RTWG has sampled groundwater wells and piezometers for both elevation data and analytical chemistry. Samples have been collected from one well at Patsville in area B-4 since 1995 (see Figure 2.1; RTWG & MWH, 2002a). Samples were collected quarterly up to 2000, and then monthly. RTWG & MWH (2002a) state that these samples have been analyzed for total and dissolved metals and trace elements; however, only results for total metals and trace elements are contained in the RTWG (2002) database. In 2002, RTWG installed two additional wells along Mill Creek downstream of the mine (subarea A-3; see Figure 2.1; RTWG & MWH, 2003a). Samples have been collected from these two wells since September 2002, and reported results indicate that they have been analyzed only for dissolved metals and trace elements. In 1999, water chemistry samples were also collected from five piezometer holes located around the perimeter of the Mill Creek mine waste material impoundments (RTWG & MWH, 2002b). One borehole drilled as part of a mine operation in the 1970s was re-opened in May 2001, and the water level has been monitored monthly (RTWG & MWH, 2002b).

Tribes

The Tribes conducted groundwater chemistry sampling from 13 wells on the DVIR in 1996 (RTWG & MWH, 2002a). The exact locations of the wells are not specified, but because they are on the reservation, they have been assigned to subareas B-6/B-7 in the RTWG (2002) database (see Figure 2.2). These samples were analyzed for total and dissolved metals and trace elements.

Other sources

The USGS collected groundwater chemistry samples in 1979 and 1980 as part of the same regional water sampling described in Section 4.3.1 (RTWG & MWH, 2002a). The dataset includes wells and springs in subareas B-0, B-5b, and B-6/B-7 (see Figure 2.2). The USGS samples were analyzed for selected dissolved metals and trace elements.

The Bureau of Health Protection Services (BHPS) has sampled the Mountain City water system intermittently since 1989 (RTWG & MWH, 2002a). The water system draws from a spring that is not affected by drainage from the mine, and thus these samples are considered potential reference samples. All of the BHPS samples were analyzed for nitrate-N, and some have also been analyzed for total metals and trace elements.

The USFS collected water samples in 1994, 1995, 1996, and 2000 from wells in the Mountain City Administrative Site, approximately 1.5 miles up the East Fork Owyhee River from Mill Creek (RTWG & MWH, 2002a). These samples were analyzed for dissolved metals and trace elements.

4.4.3 Additional studies

To supplement the available groundwater data, the Trustees will conduct a study to collect and analyze groundwater from existing wells along the East Fork Owyhee River. Samples will be analyzed for total and dissolved metal concentrations, and other parameters such as pH, calcium, magnesium, and dissolved organic carbon. This study will be coordinated with other related studies such as surface water sampling (Section 4.2.3).

Potential sampling locations for the groundwater study include existing drinking water wells in alluvial areas along the East Fork Owyhee River, including wells on the DVIR. It is anticipated that samples will be collected at up to approximately 20 locations.

The data collected from this study will be used to determine if and to what degree the groundwater aquifer, which is currently being used for drinking water, is injured.

4.5 Injury Assessment for Geologic Resources

Geologic resources include soils, sediments, rocks, and minerals that are not included in the definitions of ground and surface water resources [43 CFR § 11.14 (s)].

4.5.1 Approach

Injury determination

Based on an initial review of existing data, the relevant NRDA regulatory definitions for the evaluation of injuries to geologic resources include the following:

- Concentrations of substances sufficient to cause a toxic response to soil invertebrates [43 CFR § 11.62 (e)(9)].
- Concentrations of substances sufficient to cause a phytotoxic response such as retardation of plant growth [43 CFR § 11.62 (e)(10)].
- Concentrations of substances sufficient to have caused injury to surface water, groundwater, air, or biological resources, when exposed to geologic resources [43 CFR § 11.62 (e)(11)].

These injury definitions consist of several components. Table 4.4 summarizes the components of each definition and the approaches that may be taken in assessing each component. This section presents examples of how each component may be evaluated.

Table 4.4. Components of relevant geologic injury definitions

Injury definition	Definition components	Evaluation approach
Soil invertebrates injured when exposed to soil [43 CFR § 11.62 (e)(9)]	Soil invertebrates are injured when exposed to soil.	Compare floodplain soil concentrations to thresholds for effects in soil invertebrates.
Phytotoxic response when exposed to soil [43 CFR § 11.62 (e)(10)]	Plant survival or growth retarded when exposed to soil.	Compare concentrations of hazardous substances in floodplain soils to thresholds for effects in terrestrial plants.
		Compare vegetation community characteristics between assessment area and reference area.

The Trustees will compile, review, and evaluate existing information relevant to evaluating injury to geologic resources, including soil chemistry data, information on irrigation of fields and seasonal flooding, and any relevant Tribal cultural uses. This information will be used to evaluate the geologic resource injury definitions.

In determining injuries to geologic resources, the Trustees will compare data on concentrations of hazardous substances in soils to toxicological benchmarks indicative of injuries to soil invertebrates and plants. The U.S. Department of Energy (DOE) has developed a set of toxicological benchmarks for effects on soil invertebrates and terrestrial plants (Efroymson et al., 1997a, 1997b). These benchmark values are intended for screening level assessments, and the variations in soil properties and species sensitivity will greatly affect toxicity. However, they are useful for indicating what contaminants may be of concern in soils and worthy of further study of toxic response.

In addition to these benchmarks, the Trustees will also consider ranges for concentrations of metals and trace elements in soils that are considered phytotoxic (Kabata-Pendias and Pendias, 1992). As with the DOE thresholds, the use of these ranges is useful for screening, but actual toxicity is dependent on site-specific conditions.

The Trustees will also evaluate injuries to geologic resources by considering injuries to riparian vegetation (Section 4.7). If concentrations of hazardous substances in soils are sufficient to have caused injury to riparian vegetation via changes in growth rates, survival, or community structure, the Trustees may conclude that geologic resources are injured as a pathway to riparian vegetation.

Injury quantification

Quantification of injuries to geologic resources will include an evaluation of the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries throughout the assessment area. Injury quantification will consider the interdependent services provided by geologic resources and riparian vegetation (discussed in Section 4.7). The degree of injury may be quantified based on exceedences of criteria and standards, in combination with evidence of phytotoxicological effects, reduced crop yield, the cost of changes in irrigation management caused by poor water quality, or the cost of changes (reduced yield, reduced land value or gain resulting from perception of contamination) incurred by the Tribes, depending on results of the injury assessment.

Spatial quantification may be based on the area of riparian soils and irrigated fields exposed to elevated metals and trace elements from the mine. The Trustees will rely on aerial photographs and GIS to facilitate spatial quantification.

Pathway determination

Pathways to geologic resources include direct discharges of hazardous substances (e.g., the creation of tailings piles) and indirect pathways via surface water, groundwater, or sediments (Figure 4.5). Factors such as frequency of flooding, groundwater movement, and irrigation history may affect the transport of hazardous substances to geologic resources.

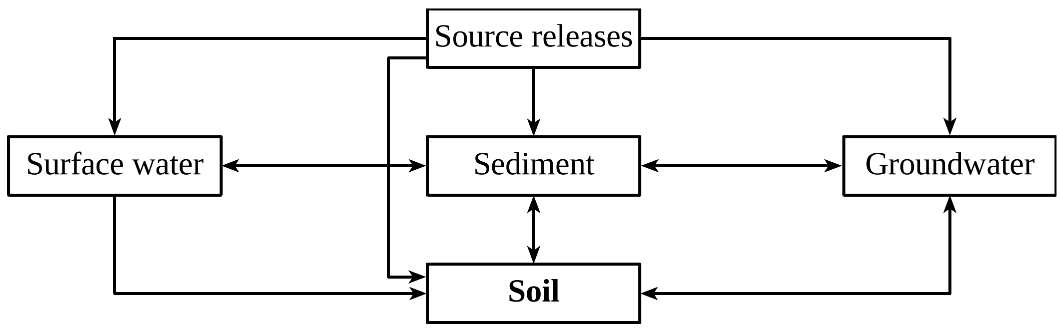

Figure 4.5. Potential geologic resource exposure pathways.

4.5.2 Available data

Few data exist on soil concentrations along Mill Creek and the East Fork Owyhee River. In 2002, RTWG conducted a study of floodplain soils in Mill Creek downstream of the mine, but no reference area samples were collected (RTWG & MWH, 2003a). Samples were collected from 42 locations and analyzed for agronomic parameters, and samples from 25 locations were also analyzed for total metals and trace elements.

RTWG also conducted a soil quality study on Mori pasture, which is west of the East Fork Owyhee River, just downstream from the confluence with Mill Creek (RTWG & MWH, 2003a). This pasture has historically been irrigated with water from a diversion in Mill Creek. Samples were collected at 15 locations in the pasture and at 5 reference locations on the east side of the East Fork Owyhee River. These samples were analyzed for total metals and trace elements.

There are no data on effects of elevated hazardous substances in Mill Creek floodplain soils, and there are no data on floodplain soil chemistry for the East Fork Owyhee River. No data on terrestrial resources (irrigated meadows, pastures, or croplands) elsewhere along the East Fork Owyhee River or on the DVIR, on potential adverse effects of terrestrial resources to East Fork Owyhee River surface water, or on irrigation water management on or off the DVIR were included in the documents reviewed.

4.5.3 Additional studies

To supplement the available groundwater data, the Trustees will collect and analyze soils from irrigated fields and riparian soils along Mill Creek and the East Fork Owyhee River. Samples will be analyzed for metal concentrations, pH, and other parameters relevant to forage growth and yield or plant and invertebrate growth and viability.

The soil studies will include the following components:

- *Collection of soils from floodplains.* Soil samples will be collected from floodplains along Mill Creek and the East Fork Owyhee River. Aerial photography and site reconnaissance will be used to identify and delineate riparian habitat and potential sampling sites in the assessment area and to identify suitable reference sites. This study will be coordinated with the Mill Creek riparian habitat survey (Section 4.7.3) to provide information on the relationship of metals and trace elements in riparian soils and habitat condition.

- *Collection of soils from irrigated fields.* Soil samples will be collected from fields irrigated with Mill Creek or East Fork Owyhee River water and from appropriate baseline areas. This study will be coordinated with surface water and sediment sampling of irrigation withdrawals (Sections 4.2.3 and 4.3.3).

It is anticipated that up to approximately 30 soil samples will be collected and analyzed for this study. The data collected from these studies will be used to (1) determine the spatial extent and degree of injury to floodplain soils along Mill Creek and the East Fork Owyhee River, and (2) determine and quantify injuries to irrigated fields.

4.6 Injury Assessment for Biological Resources — Aquatic Biota

The DOI regulations describe biological resources as fish and wildlife, including “freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species,” and other biota, including “shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition” [43 CFR § 11.14 (f)]. This section addresses aquatic biota, including fish and aquatic invertebrates. Section 4.7 discusses assessment of injuries to riparian vegetation, and Section 4.8 discusses assessment of injuries to wildlife.

Aquatic biota observed in Mill Creek and the East Fork Owyhee River include several types of benthic invertebrates and many varieties of game and nongame fish, including rainbow trout, redband trout (a subspecies of rainbow trout), brown trout, bowcut (rainbow/cutthroat trout hybrid), mountain whitefish, yellow perch, northern squawfish, speckled dace, redside shiner, suckers, and sculpin (Johnson, 2000, 2001).

4.6.1 Approach

Injury determination

Based on an initial review of existing data, the relevant NRDA regulatory definitions for the evaluation of injuries to aquatic biota resources in the assessment area include the following:

- Concentrations of a hazardous substance sufficient to cause the biological resource or its offspring to have undergone at least one of the following changes in viability: death, disease, behavioral abnormalities, cancer, physiological malfunctions (including malfunctions in reproduction), or physical deformations [43 CFR § 11.62(f)(1)(i)].

This injury definition consists of several components. Table 4.5 summarizes the components of the definition and the approaches that may be taken in assessing each component.

Table 4.5. Components of relevant aquatic biota injury definitions

Injury definition	Definition components	Evaluation approach
Cause the biological resource or its offspring to have undergone adverse changes in viability [43 CFR § 11.62 (f)(1)(i)]	Aquatic biota resources are injured when concentrations of hazardous substances are sufficient to cause changes in viability such as death, disease, behavioral abnormalities, physiological malfunctions, or physical deformation.	Compare surface water concentrations to criteria for the protection of aquatic life. Compare surface sediment concentrations to consensus-based sediment effect concentrations for benthic invertebrates. Evaluate population survey data to determine the degree of impairment of fish and benthic invertebrate communities. Evaluate results of site-specific toxicity tests on aquatic biota exposed to assessment area surface water and/or sediment.

Exceedences of ALC

As discussed in Section 4.2.1, several agencies have developed ALC for the protection of aquatic life. Exceedences of ALC will be used as a screening level indication of toxicological injuries to fish and benthic invertebrates. This initial assessment will be supplemented with an evaluation of toxicological thresholds derived from the literature. In developing toxicological thresholds, the Trustees will consider test species and their relative sensitivity to metals toxicity and site-specific water quality conditions that may influence toxicity (e.g., hardness, calcium concentration, pH, dissolved organic carbon, alkalinity).

Comparison with sediment effect concentrations

As discussed in Section 4.3.1, consensus sediment effect concentrations have been developed to predict toxicity to aquatic invertebrates. Exceedences of sediment effect concentrations will be used as a screening level indication of toxicological injuries to benthic invertebrates.

Population survey as indicator of impairment

Fish population data can be used to evaluate whether spatial patterns of fish population density and diversity are indicative of potential toxicological effects. To address this question, fish populations in potentially affected stream reaches will be compared to fish populations in reference areas.

Benthic macroinvertebrates also have been used extensively to monitor the effects of metal contamination on aquatic systems. Benthic macroinvertebrates demonstrate individual level responses (e.g., mortality, reduced growth, reduced reproductive fitness) and community level responses (e.g., reduced density, reduced species richness, community shift to more tolerant species) to metals. Metals have been shown to be toxic to benthic macroinvertebrates in laboratory and field tests (Clements, 1994; Beltman et al., 1999).

Site-specific toxicity tests

Laboratory toxicity testing is specified in the DOI regulations as a method of determining injury [43 CFR § 11.62(f)(4)(i)(E)]. The Trustees will evaluate the results of available studies of the toxicity of site surface water and sediments.

Injury quantification

Quantification of injuries to aquatic biota will include an evaluation of the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries throughout the assessment area. Quantification will rely on the degree of exceedence of criteria designed to protect aquatic life and indicators of injury such as changes in population and community structure. In addition, the Trustees will consider other factors that may affect aquatic biota such as habitat type, land use along the stream corridor, and other uses of surface water. For example, diversion of surface water for irrigation may affect the benthic invertebrate and fish populations in ways that are not related to exposure to hazardous substances. These factors will be considered in establishing appropriate baseline conditions with which to quantify the degree of injury.

Pathway determination

A preliminary evaluation of exposure pathways to aquatic resources in the assessment area suggests that pathways include direct exposure through physical contact with hazardous substances in surface water and sediment exposure through food chain processes (Figure 4.6). Food chain processes represent a significant pathway of exposure to aquatic vertebrates. Elevated concentrations of metals and trace elements in invertebrates and fish will be used to determine whether exposed water and sediments are a pathway to invertebrates and fish throughout the assessment area.

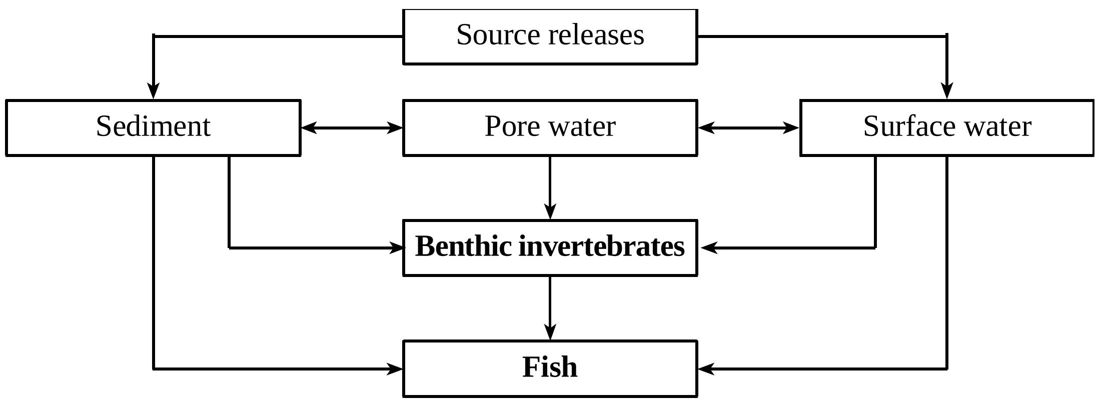

Figure 4.6. Potential exposure pathways for aquatic biota.

4.6.2 Available data

Several types of information are available on aquatic biota. The known sources are described below.

Tribes

In 1999, aquatic invertebrates were collected at four locations in the East Fork Owyhee River and two locations in Mill Creek upstream and downstream of the mine. Invertebrate samples were collected with dip nets, screens, and by overturning rocks. Samples were categorized into general types (caddisflies, mayflies, stoneflies, snails, and other) and the total number of individuals and number of different types within each category was reported (Shoshone-Paiute Tribes of Duck Valley, 2000).

In 1999 a trout fry exposure experiment was conducted in Mill Creek. Local fry collected from downstream in the East Fork Owyhee River were placed into Mill Creek at the confluence of the East Fork Owyhee River and their survival was monitored (Shoshone-Paiute Tribes of Duck Valley, 2000).

In 2002, the Tribes conducted a sampling in conjunction with the EPA that included surface water sampling at 10 sites in the East Fork of the Owyhee River and in reservoirs recharged by the river (Shoshone-Paiute Tribes of Duck Valley, 2004). Acute toxicity tests were performed using these samples on fathead minnow (*Pimephales prometlas*) and a freshwater invertebrate (*Ceriodaphnia dubia*). Toxicity testing took place over a 48 hour period of time. Sediment samples were also collected from the same locations for toxicity testing. The EPA used the macroinvertebrate *Hyalella azteca* to test for acute toxicity. Overlying water was renewed and the test organisms were fed daily. Survival and weight were measured after 7 days. No toxicity testing was conducted on sediments from Mill Creek, or from sediments from the East Fork Owyhee River just downstream of Mill Creek (subarea B-4).

In August 2002, the Tribes collected fish tissue samples from the East Fork Owyhee River, on the DVIR and upstream, and in Mountain View Reservoir (Shoshone-Paiute Tribes of Duck Valley, 2004). Fish samples were either rainbow/redband trout or brown trout and only fillets were retained for chemical analysis by EPA laboratories. A composite sample of four whole fish (three brown trout and one rainbow trout) was collected in January 2003 from the East Fork Owyhee River downstream of Wildhorse Dam and upstream of Rizzi Ranch, as a reference sample. This sample was analyzed for metals and trace elements by Analytical Laboratories in Boise, Idaho.

NDOW

Fish population and stream habitat surveys in Mill Creek and the East Fork Owyhee River were conducted by the NDOW (Johnson, 2000, 2001). Narrative reports from these surveys are available; however, raw data are not.

USFWS

The USFWS collected aquatic insect and fish tissue samples from Sheep Creek and Mountain View Reservoirs in September 1991 (Mullins et al., 1993). Samples were analyzed for trace elements and organochlorine compounds at the USFWS Patuxent Analytical Control Facility. Aquatic insect species collected included damselfly and dragonfly nymphs (*Odonata*), waterboatmen (*Corixidae*), and backswimmers (*Notonectidae*). Fish species collected included northern squawfish (*Ptychocheilus oregonensis*) and rainbow trout.

4.6.3 Additional studies

To supplement the available data on aquatic biota, the Trustees will conduct a benthic invertebrate study in Mill Creek and the East Fork Owyhee River. This study will be conducted in coordination with surface water sampling (Section 4.2.3) and sediment sampling (Section 4.3.3).

The benthic invertebrate study will include the following components:

- *Benthic invertebrate taxonomic survey*. Representative benthic invertebrate samples will be taxonomically identified and counted to determine the structure, diversity, and biological integrity of the invertebrate assemblages in Mill Creek and the East Fork Owyhee River compared to suitable reference locations.

- *Tissue analysis.* Split samples from the same locations will be collected and analyzed for metals and trace elements concentrations. These data will be used to evaluate the extent to which fish are exposed to metals and trace elements via dietary intake.

It is anticipated that invertebrate sampling will be conducted at up to approximately 15 locations. The data collected from this study will be used to (1) determine the spatial extent and degree of injury to benthic invertebrates in Mill Creek and the East Fork Owyhee River, and (2) evaluate benthic invertebrates as a pathway to other natural resources (e.g., fish).

4.7 Injury Assessment for Biological Resources — Riparian Vegetation

4.7.1 Approach

Injury determination

Based on an initial review of existing data, the relevant NRDA regulatory definitions for the evaluation of injuries to riparian vegetation include the following:

- Concentrations of a hazardous substance sufficient to cause the biological resource or its offspring to have undergone at least one of the following changes in viability: death, disease . . . cancer, physiological malfunctions (including malfunctions in reproduction), or physical deformations [43 CFR § 11.62(f)(1)(i)].

This injury definition consists of several components. Table 4.6 summarizes the components of the definition and the approaches that may be taken in assessing each component.

Table 4.6. Components of relevant riparian vegetation biological injury definitions

Injury definition	Definition components	Evaluation approach
Cause the biological resource or its offspring to have undergone adverse changes in viability [43 CFR § 11.62 (f)(1)(i)]	Riparian vegetation resources are injured when concentrations of hazardous substances are sufficient to cause changes in viability such as death, disease, physiological malfunctions, or physical deformation.	Compare concentrations of hazardous substances in floodplain soils to thresholds for phytotoxic effects in terrestrial plants. Evaluate field vegetation survey data and aerial photographs to determine the degree of impairment of riparian vegetation.

The Trustees will compile, review, and evaluate existing information relevant to evaluating injury to riparian vegetation, including floodplain soil chemistry data, aerial photographs, and any relevant Tribal cultural use of riparian vegetation.

The Trustees will compare concentrations of hazardous substances in floodplain soils to phytotoxic thresholds as described in Section 4.5.1, as an indication of injuries to riparian vegetation. The Trustees will also evaluate data from field surveys of riparian vegetation and aerial photographs to determine the degree of impairment to riparian vegetation.

Injury quantification

Quantification of injuries to riparian vegetation resources will include an evaluation of the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries throughout the assessment area. For Mill Creek, the quantification may be based on comparisons of vegetation cover and possibly other field measures to baseline conditions. Areas of reduced vegetation will be categorized and quantified spatially using GIS. Information on service losses resulting from the contamination of riparian vegetation will also be used in quantifying injuries. This may require additional interview and survey work to assess whether human uses have changed as a result of releases of hazardous substances from the mine, and if so, to what degree the uses have changed (see Section 4.9).

Quantification of injuries to irrigated fields may be based on the area of fields exposed to elevated metals and trace elements from the mine, reduced crop yield, the cost of changes in irrigation management caused by poor water quality, or the cost of changes (reduced yield, reduced land value or gain resulting from perception of contamination) incurred by the Tribes resulting from mine-caused contamination in the irrigation water, depending on results of the injury assessment.

Pathway determination

The primary exposure route for riparian vegetation is uptake from geologic resources and surface water via irrigation and flooding (Figure 4.7). Earlier sections of this chapter described how pathways to these resources will be evaluated.

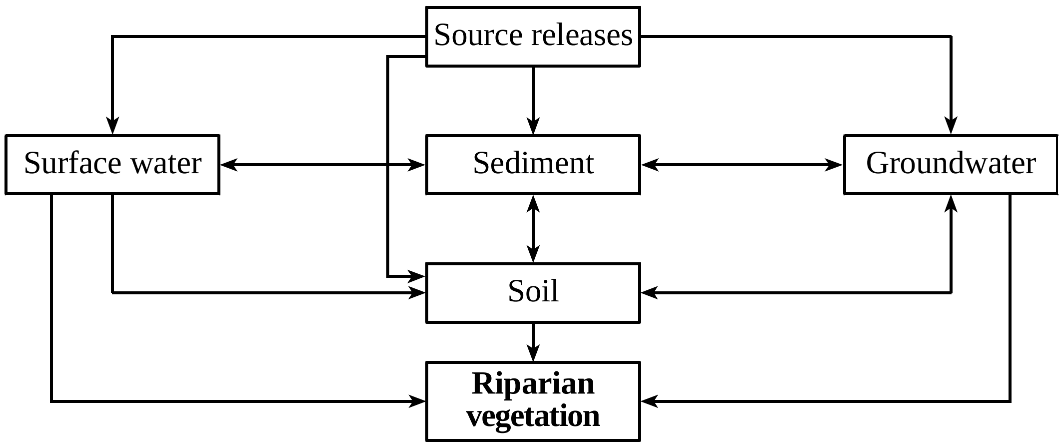

Figure 4.7. Potential exposure pathways for riparian vegetation.

4.7.2 Available data

Data on riparian vegetation are limited. The Tribes conducted an inventory of their priority plant species at sample locations along the East Fork Owyhee River (Shoshone-Paiute Tribes of Duck Valley, 2004). Observations were made at Rizzi Ranch upstream of Mill Creek, at several locations along the East Fork Owyhee River downstream of the DVIR boundary, and in Sheep Creek and Mountain View Reservoirs. This study also inventoried other plant taxa documented at the sample locations. No quantitative plant community or vegetation structure data were collected from this survey.

On behalf of the Shoshone-Paiute Tribes, Confluence Consulting, Inc. (2003) conducted an assessment of the East Fork Owyhee River in June 2003. This assessment included an evaluation of the percent cover of different types of riparian vegetation along three reaches of the river between the Mountain City Stream gage station and approximately 2.4 miles downstream.

Johnson (2000, 2001) included narrative descriptions of the condition of riparian vegetation along Mill Creek and the East Fork Owyhee River in his trip reports.

The two floodplain soil studies that RTWG & MWH (2003a) conducted in 2002 may also be used to evaluate injuries to riparian resources. These studies are described in Section 4.5.2.

In summary, there is little quantitative information available on the condition of riparian resources of Mill Creek and the East Fork Owyhee River downstream of the Rio Tinto Mine, relative to baseline conditions. There is also no information available on uptake of metals or toxicity of site soils to vegetation.

4.7.3 Additional studies

To supplement the available data on riparian vegetation, the Trustees will conduct a riparian habitat survey along Mill Creek. The purpose of the survey will be to compare soil metal concentrations, vegetation cover, vegetation diversity, and habitat complexity to baseline conditions to assess the viability of vegetation and the availability and quality of habitat to support biological resources. This study will be conducted in coordination with floodplain soil sampling in Mill Creek (Section 4.5.3).

The data collected from this study will be used to determine the spatial extent and degree of injury to riparian habitat along Mill Creek.

4.8 Injury Assessment for Biological Resources — Wildlife

4.8.1 Approach

Injury determination

Based on an initial review of existing data, the relevant NRDA regulatory definitions for the evaluation of injuries to wildlife include the following:

- Concentrations of a hazardous substance sufficient to cause the biological resource or its offspring to have undergone at least one of the following changes in viability: death, disease, behavioral abnormalities, cancer, physiological malfunctions (including malfunctions in reproduction), or physical deformations [43 CFR § 11.62(f)(1)(i)].

Table 4.7 summarizes this definition and the approaches that may be taken in the assessment.

The Trustees will compile, review, and evaluate existing information relevant to evaluating injury to wildlife, including data on the occurrence and distribution of wildlife species that provide services of special significance (e.g., state or federal listed species, species of cultural importance to the Tribe).

Table 4.7. Components of relevant wildlife biological injury definitions

Injury definition	Definition components	Evaluation approach
Cause the biological resource or its offspring to have undergone adverse changes in viability [43 CFR § 11.62 (f)(1)(i)]	Wildlife resources are injured when releases of hazardous substances have impaired the ability of habitat to support populations.	Evaluate population and habitat survey data to determine the degree of impairment of wildlife.

Information on habitat use and populations of selected species of interest, such as the Columbia spotted frog (*Rana luteiventris*), will be used to assess injury to wildlife. In addition, the results of the evaluation of riparian vegetation (Section 4.7) may be used to determine if wildlife are injured via injuries to their habitat.

Injury quantification

Quantification of injuries to wildlife resources will include an evaluation of the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries throughout the assessment area. If information on direct injuries is available, it will be used; however, it is most likely that injury will be addressed as reduction of habitat quality and quantified in conjunction with geologic and riparian vegetation resources.

Pathway determination

The primary pathway of hazardous substances to wildlife is ingestion of vegetation, surface water, or incidental ingestion of soils and sediments. Pathways to these resources have been discussed previously in this chapter. The Trustees will develop a conceptual model of exposure of wildlife receptors via ingestion or via degradation of habitat quality.

4.8.2 Available data

There are no currently available quantitative or qualitative data on wildlife resources along Mill Creek or the East Fork Owyhee River.

4.8.3 Additional studies

The Trustees will conduct a survey of Columbia spotted frog habitat and population along Mill Creek, and possibly along the East Fork Owyhee River between the confluence with Mill Creek and the DVIR boundary. The purpose of the study is to (1) determine the current population of Columbia spotted frogs along Mill Creek, (2) determine the suitability of baseline habitat that would be expected along Mill Creek absent releases of hazardous substances from the mine site, and (3) to estimate the expected baseline Columbia spotted frog population along Mill Creek. This survey will be conducted in conjunction with the Mill Creek riparian habitat survey described in Section 4.7.3.

4.9 Tribal Cultural Use Service Loss Assessment

Healthy natural resources and ecosystems are highly valued by the Shoshone-Paiute Tribes of the Duck Valley Indian Reservation. This high value derives from the integral part that natural resources play in the Tribes' culture, spirituality and religion, economy, and subsistence (Walker Research Group, Ltd., 2002a). A close relationship with healthy, functioning ecosystems and natural resources is essential to the Tribes' way of life, identity, history, culture, and overall well being.

Traditional uses by the Tribe of many natural resources persist today (Walker Research Group, Ltd., 2002a). Willows and other trees are used to build ceremonial and community structures, and for basketry and the construction of cradleboards (Walker Research Group, Ltd., 2002b). Tribal members make bows and arrows from several types of wood, including willows, serviceberry, and chokecherry. A wide assortment of plants provide food and medicines, and many Tribal members rely on traditional foods for the bulk of their diet. Animal hides and plants are also used for constructing traditional clothing and in traditional ceremonial roles. The dependence of the Tribes on natural resources and uses of the resources is connected to their spiritual and cultural values and the belief that the Creator gave such things to the people to use properly and respectfully.

When an ecosystem or natural resource is negatively impacted, it can adversely affect the flow of natural resource services provided to the Tribes. Therefore, the NRDA will include an evaluation of the loss of cultural use services suffered by the Tribes as a result of hazardous substance releases from the Rio Tinto Mine.

4.9.1 Approach

Injury assessment

Injuries to natural resources as described in Sections 4.2 to 4.8 will be used to assess Tribal cultural use service losses. In addition, service losses may be quantified directly by measuring changes in services provided by natural resources (see following section on injury quantification).

Injury quantification

The objective of this Tribal cultural use service loss assessment is to determine the extent to which the quality and quantity of natural resource services specific to Tribal uses have been reduced as a result of the release of hazardous substances, in comparison to baseline conditions, as that term is defined in the NRDA regulations [43 CFR §11.14(e)]. Services, as defined in the regulations, include provision of habitat, food and other needs of biological resources, recreation, other products or services used by humans, flood control, groundwater recharge, waste assimilation, and other such functions that may be provided by natural resources [43 CFR §11.14(nn) and §11.71(e)].

The DOI NRDA regulations allow for direct quantification of effects on resources by measuring changes in the services provided by the resources rather than by quantifying the changes in the resource itself, if certain conditions are met [43 CFR §11.71(f)]:

- The change in the services from baseline can be demonstrated to have resulted from the injury to the natural resource.
- The extent of change in the services resulting from the injury can be measured without also calculating the extent of change in the resource.
- The services to be measured are anticipated to provide a better indication of damages caused by the injury than would direct quantification of the injury itself.

This assessment is intended to provide sufficient information to quantify injuries by identifying the change in the level of Tribal-specific services resulting from the injuries. Because the degree of service loss to the Tribes may not be directly correlated with the degree of injury to natural resources, it is anticipated that the identification of lost or reduced services would provide a better indication of potential damages than would direct quantification of the injuries to the resources themselves.

The Trustees will compile, review, and evaluate existing information relevant to evaluating cultural use service losses, including information on historical and current Tribal cultural use services provided by natural resources in the area. Information will include information on historical and current Tribal cultural use services provided by natural resources in the area, natural resources important to the Tribe for cultural or religious uses, and information on any service loss changes in uses or perceptions related to releases of hazardous substances from the mine.

The Trustees will identify resources and their uses by the Tribes, identify how these resources and the services they provide are interrelated based on traditional practices and physical and natural processes, and determine how injuries to one or more natural resources in the assessment area have affected the level of Tribal services provided by these resources, compared to the level of services that would have existed if not for releases from the Rio Tinto Mine. The quantification may be based on the number of Tribal members affected, the degree of the effect, or the spatial extent of the area(s) where cultural use service losses have occurred.

Pathway considerations

The primary transport of hazardous substances through the Mill Creek and East Fork Owyhee River watersheds has most likely occurred through the surface water pathway. Thus, the resources most likely to be injured include surface water and other resources directly and regularly exposed to surface water, including aquatic organisms, riparian resources, and vegetation. The Trustees' approach to determining pathways to these resources is described in previous sections.

Additional pathways from exposed resources to Tribal resources and receptors are expected to be identified through the additional study described in Section 4.9.3.

4.9.2 Available data

Available data on Tribal cultural uses include ethnographic assessments of Shoshone-Paiute views and uses of their environment (Walker Research Group, Ltd., 2002a, 2002b), and a vegetative use and cultural survey conducted by the Tribes (Shoshone-Paiute Tribes of Duck Valley, 2004).

4.9.3 Additional studies

The Trustees will conduct additional research to supplement the available information on the range of Tribal uses and services that are likely to have been affected (i.e., reduced or lost) by hazardous substance exposure of surface water, riparian resources, and other resources in the Mill Creek and East Fork of the Owyhee River watersheds. Additional research may include the following:

- Development of a detailed inventory of resources, including plants, animals, birds, fish, minerals, and other natural and cultural resources that are used by Tribal members.

- Determination of how the resources identified in the inventory were and are used by the Shoshone-Paiute Tribes (i.e., what services they provide). This task will rely on interviews, literature reviews, and other appropriate sources.

- Development of a Tribal-specific model (i.e., dependency web or influence diagram) to illustrate the relationships between the resources identified in the inventory and the Tribal services those resources provide. Examples of such models include work conducted by Harris and Harper (1998, 2000).

- Determination of the extent to which injuries to one or more natural resources in the assessment area have affected the level of Tribal services provided by those resources, compared to the level of services that would have existed if not for releases from the Rio Tinto Mine.

- Field reconnaissance and inventory of baseline or reference areas to distinguish absence or reduction in resources in the assessment area because of reasons other than mine releases. Inventory methods for selecting and evaluating baseline or reference areas will be developed to identify the resources that would most likely exist in the assessment area were it not for the release of hazardous substances from the Rio Tinto Mine.

5. Restoration Planning Approach

This chapter describes the Trustees' approach to conducting restoration planning to identify and select restoration projects that will restore injured resources and services to baseline and compensate for interim losses. At this time, the Trustees are not able to prepare a complete RCDP, which is identified in the DOI NRDA regulations as a possible component of an Assessment Plan [(43 CFR §11.81)]. A primary purpose of an RCDP is to identify potential restoration alternatives, select the preferred alternative(s), and estimate the cost for the preferred alternative(s) [43 CFR §11.81(a)(1)]. Since injuries and associated services losses have not yet been determined or quantified, the Trustees are unable to identify and select the preferred restoration alternative(s) to address injuries and service losses. Therefore, the Trustees will prepare an RCDP after the injury assessment is complete, which is an option under the DOI NRDA regulations [43 CFR §11.81(d)(1)]. The information presented in this chapter describes the overall approach that the Trustees will take toward restoration planning.

5.1 Overall Approach

The Trustees for the Rio Tinto Mine NRDA are committed to restoring injured resources and their services to baseline and to compensating for the interim losses that occur until the time that restoration to baseline occurs. The Trustees will consider a range of potential restoration options to accomplish these goals, including control of sources of hazardous substance releases from the mine or other areas where such hazardous substances have come to be located and are being re-released into the environment, as well as other actions to restore, rehabilitate, replace, and/or acquire the equivalent of the injured resources [43 CFR §11.82(b)(1)]. Any restoration actions to address releases or re-releases of hazardous substances, if necessary, will take into account and be in addition to any response actions taken at the site. Actions to replace or acquire the equivalent of the injured resources could include on-site or off-site habitat restoration/rehabilitation, the purchasing of vulnerable lands or conservation easements for resource protection and management, or the purchasing of resource rights such as water use rights or public/Tribal access.

An important element in restoration planning is determining the appropriate type and scale of restoration actions. For restoration actions intended to control any ongoing hazardous substance releases or re-releases, the scale of such actions is defined by the type and amount of source control actions that are necessary to allow injured resources and their services to return to baseline.

For actions that will provide natural resource services that are "the same or substantially similar" to the services lost because of hazardous substance releases [43 CFR §11.82(b)(1)(ii)], the Trustees anticipate using a habitat equivalency analysis (HEA) approach to scaling. HEA was developed by the U.S. National Oceanic and Atmospheric Administration (NOAA) and has been applied by many natural resource trustees to determine the amount of restoration needed to compensate for losses of natural resources resulting from oil spills, hazardous substance releases, or physical injuries such as vessel groundings. Restoration is scaled so that the ecological service gains provided at compensation sites equal the cumulative service losses at the injured site, where ecological services are defined as the physical, chemical, or biological functions that one natural resource provides for another (NOAA, 2000). Thus, HEA is used to determine the amount of restoration that is required to compensate for past, current, and future (i.e., residual to any cleanup) injuries.

One of the key benefits of HEA is that it allows trustees and potentially responsible parties involved in NRDA to focus on scaling and planning restoration. Using HEA rather than economic valuation studies to scale restoration can reduce the cost and time required for an assessment and can focus efforts directly on restoration. In practice, HEA calculations are often used as a tool in settlement discussions between trustees and responsible parties. HEA calculations also have been used in a litigated NRDA case as the basis for compensation claim by NOAA (United States v. Melvin A. Fisher et al., Case No. 92-10027-CIVIL-DAVIS).

Another benefit of HEA is that it explicitly creates a connection between services lost because of injury and services gained through restoration. The connection provides a clear demonstration to the public that the trustees have fulfilled their mandate of compensating the public for the interim losses of natural resources and their services. The implicit assumption of HEA is that the public can be compensated with direct service-to-service scaling, where the services provided by proposed restoration actions are of similar type, quality, and value as the services lost because of injury (NOAA, 2000).

Once restoration actions are scaled, using either return to baseline or HEA as the basis of the scaling, the cost of implementing the actions can be estimated. These costs then will form the basis of the Trustees' NRDA claim (43 CFR §11.15).

5.2 Methods

Restoration and compensation planning will involve the following steps:

- Identifying and quantifying resource service losses resulting from injuries to natural resources.

- Identifying potential restoration projects to restore injured resources and their services to baseline and compensate for interim losses.

- Developing criteria for evaluating restoration projects that reflect the goals, objectives, and priorities of the Trustees.

- Screening, ranking, and selecting restoration projects based on the criteria identified above.

- Scaling the selected restoration projects such that restoration gains appropriately compensate for injury losses.

- Developing costs for restoration projects or project categories that include administrative, operations and maintenance, and monitoring costs.

These steps are described in more detail below.

5.2.1 Identifying service losses

For the purposes of injury assessment and injury quantification, the Trustees have divided the natural resources of the assessment area into the following categories, which were described in Chapter 4:

- surface water
- sediments
- groundwater
- geologic (floodplain and irrigated soils)
- aquatic biota
- riparian vegetation
- wildlife.

For the purposes of restoration planning, the Trustees will consider not only injuries to the natural resources themselves, but also the loss of services that these natural resources provide. Services may be ecological services (e.g., capability of a habitat to support biota) or human use services (e.g., availability of a resource for human consumption). The Trustees anticipate that the following services may be important in the NRDA:

- aquatic habitat
- riparian habitat
- agricultural production
- Tribal uses.

Aquatic habitat services are the ability of the surface water and sediment natural resources to provide habitat for fish, macroinvertebrates, and other wildlife that live primarily in the waters of the streams. Similarly, riparian habitat services are the ability of riparian areas to support riparian vegetation and wildlife. Agricultural production services are the ability of irrigated soils to support the growth of crops or livestock. Tribal use services are any uses of the natural resources in the assessment area by members of the Tribes. These uses may include activities that have social, cultural, religious, recreational, or subsistence value.

5.2.2 Developing criteria and selecting restoration projects

The Trustees will develop a list of potential restoration projects that provide restoration or enhancement of the same service categories as those lost because of injuries. Restoration projects may include hazardous substance source control actions or on- and off-site measures to restore aquatic and riparian habitats and improve fish, macroinvertebrate, plant, and wildlife populations. A single restoration project may address multiple types of service losses.

The Trustees will first develop a list of potential restoration actions based on information from the ongoing site RI/FS (for potential source control actions), on solicitations from the public, from within Trustee or other resource agencies, or from other interested parties, or on internal deliberations. The Trustees will then evaluate the list of potential restoration projects using the criteria listed in the DOI NRDA regulations [43 CFR §11.82(d)] as well as such criteria as the following:

- *Consistency with Trustee agencies' restoration goals:* Consideration will be given to the mandates or goals of Trustee agencies in general for resource restoration, protection, and management.
- *Connection ("nexus") to injuries*: Under this criterion, projects that benefit the same type of resource or services that were lost as a result of injuries (e.g., instream habitat, access for Tribal uses) are preferred over projects that benefit other activities or resources.
- *Likelihood of success*: The Trustees will consider factors affecting the likely success of a project. Projects that have less risk or uncertainty (e.g., technical, political) regarding the potential to succeed are preferred under this criterion. The Trustees will also consider the ability to monitor and evaluate project success, and the ability to correct problems that arise during implementation.
- *Opportunities for partners or collaboration*: The Trustees will consider the possibility of receiving matching funds or other forms of support to increase the expected benefits of a proposed project. The Trustees will also evaluate potential coordination with other ongoing or proposed projects.

- *Lack of alternative funding sources*: The Trustees will consider only projects that otherwise would not be funded in the foreseeable future. The Trustees will not fund projects that are scheduled to be implemented with funds from another source.

5.2.3 Scaling selected restoration alternatives

As described above, HEA allows for the scaling of selected restoration actions so that the service gains provided through restoration projects equal the cumulative service losses from injuries to natural resources. The information required to quantify the habitat injury loss or "debits" may include 1) time periods of any past and future injury, 2) spatial extent of injury, 3) quantification of lost services over space and time compared to baseline conditions, and 4) a discount rate (typically 3%). Debits are commonly expressed in units that describe both space and time, such as "acre-years," where one acre-year represents the loss of one habitat acre for one year.

The Trustees will incorporate in the scaling calculations information from the injury assessment and information on how quickly the natural resources are expected to recover to baseline conditions under different remediation scenarios. The resources of the impacted area have not recovered, despite reclamation efforts by the RTWG and NDEP (RTWG & MWH, 2001). It is expected that injuries may continue well into the future, as will associated losses of natural resource services.

The Trustees will evaluate several scenarios to estimate the duration of injury and the recovery to baseline conditions. The scenarios will assume different levels of remediation effort at the site and associated recovery rates of impacted resources. One scenario may be that the impacted resources will not recover without additional source control actions. In this case, the Trustees will incorporate the need for such restoration to ensure full recovery of the impacted areas to baseline conditions.

5.2.4 Estimating restoration costs

The costs of the preferred restoration alternatives will provide the basis for the damage claim. The costs of a restoration project will include all planning, permitting, implementation, and (if applicable) agency oversight, monitoring, and compliance costs.

6. Quality Assurance Project Plan

6.1 Introduction

This Quality Assurance Project Plan (QAPP) has been developed to support studies that may be performed as part of the Rio Tinto NRDA. Under the NRDA regulations [43 CFR § 11.31], the QAPP is required to develop procedures to ensure data quality and reliability. This QAPP is intended to provide quality QA/QC procedures, guidance, and targets for use in future studies conducted for the NRDA. It is not intended to provide a rigid set of predetermined steps with which all studies must conform or against which data quality is measured, nor is it intended that existing data available for use in the NRDA must adhere to each of the elements presented in this QAPP. Ultimately, the quality and usability of data are based on methods employed in conducting studies, the expertise of study investigators, and the intended uses of the data. The QAPP has been designed to be consistent with the NCP and EPA's Guidelines and Specifications for Preparing Quality Assurance Project Plans (U.S. EPA, 1998).

The elements outlined in this plan are designed to:

- provide procedures and criteria for maintaining and documenting custody and traceability of environmental samples
- provide procedures and outline QA/QC practices for the sampling, collection, and transporting of samples
- outline data quality objectives (DQOs) and data quality indicators
- provide a consistent and documented set of QA/QC procedures for the preparation and analysis of samples
- help ensure that data are sufficiently complete, comparable, representative, unbiased, and precise so as to be suitable for their intended uses.

Before the implementation of NRDA studies, study-specific SAPs providing descriptions of study objectives, sampling methods, and QA/QC measures will be developed. These SAPs will be appended to this QAPP, as developed, to provide an ongoing record of methods and procedures employed in the assessment. SAPs will be developed and updated as methods and procedures are reviewed and accepted for use.

6.2 Project Organization and Responsibility

Defining project organization, roles, and responsibilities helps ensure that individuals are aware of specific areas of responsibility that contribute to data quality. However, fixed organizational roles and responsibilities are not necessary and may vary by study or task. An example of project quality assurance organization, including positions with responsibility for supervising or implementing quality assurance activities, is shown in Figure 6.1. Key positions and lines of communication and coordination are indicated. Descriptions of specific quality assurance responsibilities of key project staff are included below. Only the project positions related directly to QA/QC are described; other positions may be described in associated project plans. Specific individuals and laboratories selected to work on an investigation will be summarized and appended to this QAPP or included in study-specific SAPs when they are established.

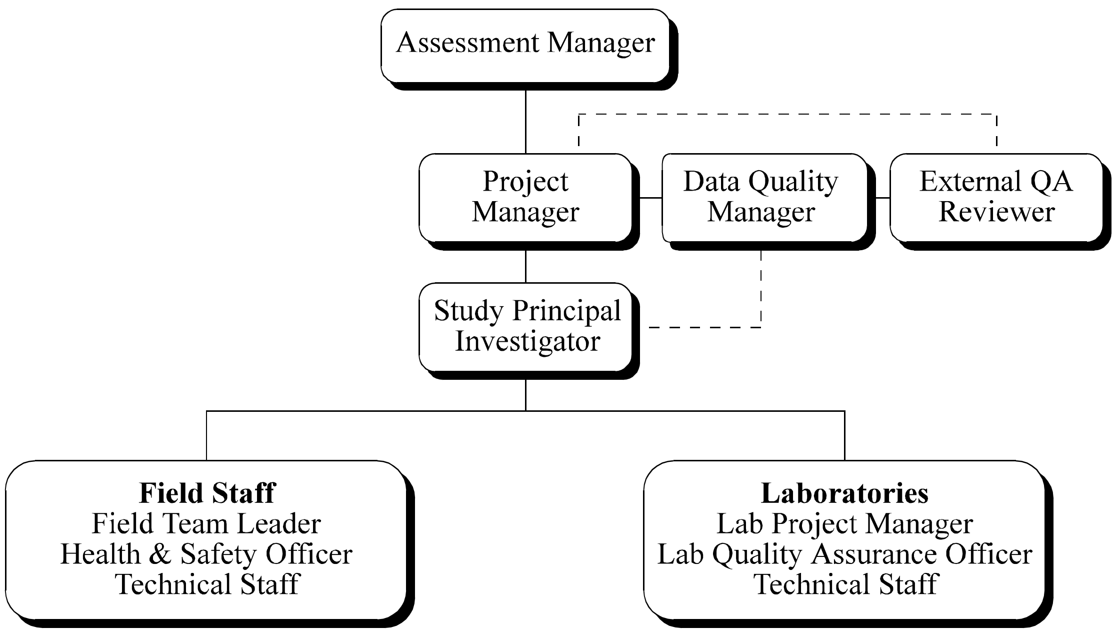

Figure 6.1. Example of project quality assurance organization.

6.2.1 Assessment Manager and Project Manager

The Assessment Manager (AM) is responsible for all technical, financial, and administrative aspects of the project. The Project Manager (PM) supports the AM and is responsible for producing quality data and work products for this project within allotted schedules and budgets. Duties of both include executing all phases of the project and efficiently applying the full resources of the project team in accordance with the project plans. Specific QA-related duties of the AM and the PM can include:

- coordinating the development of a project scope, project plans, and data quality objectives
- ensuring that written instructions in the form of standard operating procedures (SOPs) and/or associated SAPs are available for activities that affect data quality
- monitoring investigative tasks for their compliance with plans, written procedures, and QC criteria
- monitoring the performance of subcontractors in regard to technical performance and specifications, administrative requirements, and budgetary controls
- participating in performance and/or systems audits and monitoring the implementation of corrective actions
- reviewing, evaluating, and interpreting data collected as part of this investigation
- supervising the preparation of project documents, deliverables, and reports
- verifying that all key conclusions, recommendations, and project documents are subjected to independent technical review, as scheduled in the project plans.

6.2.2 Data Quality Manager

A Data Quality Manager can be assigned to be responsible for overall implementation of the QAPP. Duties include conducting activities to ensure compliance with the QAPP, reviewing final QA reports, preparing and submitting QA project reports to the AM and PM, providing technical QA assistance, conducting and approving corrective actions, training field staff in QA procedures, and conducting audits, as necessary. Specific tasks may include:

- assisting the project team with the development of data quality objectives
- managing the preparation of and reviewing data validation reports
- submitting QA reports and corrective actions to the PM
- ensuring that data quality, data validation, and QA information are complete and are reported in the required deliverable format
- communicating and documenting corrective actions
- maintaining a copy of the QAPP
- supervising laboratory audits and surveillance
- ensuring that written instructions in the SOPs and SAPs are available for activities that affect data quality
- monitoring investigative tasks for their compliance with plans, written procedures, and QC criteria
- monitoring the performance of subcontractors in regard to technical performance and specifications, administrative requirements, and budgetary controls
- reviewing, evaluating, and interpreting data collected as part of this investigation.

6.2.3 External QA Reviewer

External QA Reviewers can review QA documentation and procedures, perform data validation, and perform field and laboratory audits if needed.

6.2.4 Principal Investigator

Study-specific Principal Investigators (PIs) ensure that QA guidance and requirements are followed. The PI or the designee will note significant deviations from the QAPP for the study. Significant deviations will be recorded and promptly reported to the PM and Data Quality Manager. In addition, the PI typically is responsible for reviewing and interpreting study data and preparing reports.

6.2.5 Field Team Leader

The Field Team Leader (FTL) supervises day-to-day field investigations, including sample collection, field observations, and field measurements. The FTL generally is responsible for all field QA procedures defined in the QAPP, and in associated SAPs and SOPs. Specific responsibilities may include:

- implementing the field investigation in accordance with project plans
- supervising field staff and subcontractors to monitor that appropriate sampling, testing, measurement, and recordkeeping procedures are followed
- ensuring the proper use of SOPs associated with data collection and equipment operation
- monitoring the collection, transport, handling, and custody of all field samples, including field QA/QC samples
- coordinating the transfer of field data, including field sampling records, chain-of-custody records, and field logbooks
- informing the PI and Data Quality Manager when problems occur, and communicating and documenting any corrective actions that are taken.

6.2.6 Laboratory Project Manager

A Laboratory Project Manager can be responsible for monitoring and documenting the quality of laboratory work. Duties may include:

- ensuring that the staff and resources required to produce quality results in a timely manner are committed to the project
- ensuring that the staff are adequately trained in the procedures that they are using so that they are capable of producing high quality results and detecting situations not within the QA limits of the project
- ensuring that the stated analytical methods and laboratory procedures are followed and the laboratory's compliance is documented
- maintaining a laboratory QA manual and documenting that its procedures are followed
- ensuring that laboratory reports are complete and reported in the required deliverable format

- communicating, managing, and documenting all corrective actions initiated at the laboratory

- notifying the Data Quality Manager, within one working day of discovery at the laboratory, of any situations that will potentially result in qualification of analytical data.

6.2.7 Technical staff

Project technical staff represent a variety of technical disciplines and expertise. Technical staff should have adequate education, training, and specific experience to perform individual tasks as assigned. They are required to read and understand any documents describing the technical procedures and plans that they are responsible for implementing.

6.3 Quality Assurance Objectives for Measurement Data

6.3.1 Overview

The overall QA objectives are to help ensure that the data collected are of known and acceptable quality for their intended uses. QA objectives are qualitative and quantitative statements that aid in specifying the overall quality of data required to support various data uses. These objectives often are expressed in terms of accuracy, precision, completeness, comparability, representativeness, and sensitivity. Laboratories involved with the analysis of samples collected in support of this NRDA will make use of various QC samples such as standard reference materials (SRMs), matrix spikes, and replicates to assess adherence to the QA objectives discussed in the following sections and in specific laboratory QA/QC plans. Field and laboratory QC targets for chemical analyses, frequency, applicable matrices, and acceptance criteria are listed in Table 6.1.

Because numeric QC criteria are specific to a study, method, or laboratory, criteria are not included in this QAPP. When appropriate, criteria can be established when study and method procedures are approved; such criteria will be appended to this QAPP or included in study-specific SAPs. Criteria will be determined based on factors that may include:

- specific analytical methods and accepted industry standards of practice
- matrix-specific control limits for acceptable sample recovery, accuracy, or precision
- historical laboratory performance of selected analytical methods
- intended uses of the data.

Table 6.1. Laboratory and field quality control sample targets for chemical analyses

QC element	Target frequency	Applicable matrices	Target acceptance criteria
Method blank	1 in 20 samples	S, SW, T	Method dependent
Laboratory duplicate	1 in 20 samples	S, SW, T	Method dependent
Matrix spike	1 in 20 samples	S, SW, T	Method dependent
Standard reference material	1 in 20 samples	S, SW, T	Method dependent
Equipment blank	1 in 20 samples	SW	Study dependent
Field duplicate	1 in 20 samples	S, SW, T	Study dependent
Surrogates	All samples for organics analysis	S, SW, T	Method dependent
Laboratory control sample	1 in 20 samples	S, SW, T	Method dependent

S = sediment; SW = surface water; T = tissue.

Where statistically generated or accepted industry standards of practice are not available, QC criteria may be defined by the Data Quality Manager working with the Laboratory QA Officer and PIs.

6.3.2 Quality control metrics

Accuracy

Accuracy is a quantitative measure of how close a measured value lies to the actual or “known” value. Sampling accuracy is partially evaluated by analyzing field QC samples such as field blanks, trip blanks, and rinsates (or equipment blanks). In these cases, the “true” concentration is assumed to be not detectable, and any detected analytes may indicate a positive bias in associated environmental sample data.

Laboratory accuracy is assessed using sample (matrix) spikes and other QC samples. For example, a sample (or blank) may be spiked with an inorganic compound of known concentration and the average percent recovery (%R) calculated as a measurement of accuracy. A second procedure is to analyze a standard (e.g., SRMs or other certified reference materials) and calculate the %R for that known standard. As an additional, independent check on laboratory accuracy, blind SRMs submitted as field samples may be used.

Accuracy criteria are established statistically from historical performance data, and often are based on confidence intervals set about the mean. Where historical data are not adequate for statistical calculations, criteria may be set by the Laboratory Project Manager, Data Quality Manager, and PIs. Accuracy criteria will be appended to this QAPP or included in study-specific SAPs when established. Accuracy may be assessed during the data validation or data quality assessment stage of these investigations.

Precision

Precision is a measure of the reproducibility of analytical results under a given set of conditions. The overall precision of a set of measurements is determined by both sampling and laboratory variables. Reproducibility is affected by sample collection procedures, matrix variations, the extraction procedure, and the analytical method.

Field precision typically is evaluated using sample replicates, which are usually duplicate or triplicate samples. Sample replicates may be generated by homogenizing the sample, splitting the sample into several containers, and initiating a blind submittal to the laboratory with unique sample numbers. For a duplicate sample, precision of the measurement process (sampling and analysis) is expressed as:

$$\text{Relative Percent Difference (RPD)} = \frac{(\text{Duplicate Sample Result - Sample Result})}{(\text{Duplicate Sample Result + Sample Result})} \text{ x } 100.$$

For a triplicate analysis, precision of the sampling and analysis process is expressed as:

$$\text{Percent Relative Standard Deviation (\% RSD)} = \frac{\sigma_{\text{n-1}}}{\text{Mean}} \text{ x } 100,$$

where σ_{n-1} is the standard deviation of the three measurements.

Laboratory precision typically is evaluated using laboratory duplicates, matrix spike duplicates, or laboratory control sample or SRM duplicate sample analysis. Duplicates prepared in the laboratory are generated before sample digestion. Laboratory precision is also expressed as the RPD between a sample and its duplicate, or as the %RSD for three values.

Precision criteria are established statistically from historical performance data, and are usually based on the upper confidence interval set at two standard deviations above the mean. Where historical data are not adequate for statistical calculations, criteria may be set by the Laboratory Project Manager, Data Quality Manager, and PIs. Precision criteria will be appended to this QAPP or included in study-specific SAPs, when established.

Completeness

Completeness is defined as the percentage of measurement data that remain valid after discarding any invalid data during the field or laboratory QC review process. A completeness check may be performed following a data validation process. Analytical completeness goals may vary depending on study type, methods, and intended uses of the data.

Analytical data completeness will be calculated by analyte. The percent of valid data is 100 times the number of sample results not qualified as unusable (R) divided by the total number of samples analyzed. Data qualified as estimated (J) because of minor QC deviations (e.g., laboratory duplicate RPD exceeded) will be considered valid.

Comparability

Comparability is a qualitative parameter expressing the confidence with which one dataset can be compared to another. Comparability is facilitated by use of consistent sampling procedures, standardized analytical methods, and consistent reporting limits and units. Data comparability is evaluated using professional judgment.

Representativeness

Representativeness expresses the degree to which data accurately and precisely represent a defined or particular characteristic of a population, parameter variations at a sampling point, a processed condition, or an environmental condition. Representativeness is a qualitative parameter that is dependent on the proper design of the sampling program and proper laboratory protocol. Sampling designs for this investigation will be intended to provide data representative of sampled conditions. During development of SAPs and SOPs, consideration will be given to existing analytical data, environmental setting, and potential industrial sources. Representativeness will be satisfied by ensuring that the sampling plan is followed.

Sensitivity

Detection limit targets for each analyte and matrix will be appended to this QAPP or included in study-specific SAPs as they are established.

6.4 Sampling Procedures

6.4.1 Sample collection

Samples are collected and handled in accordance with the procedures contained in SOPs or associated SAPs. These documents typically describe sample collection, handling, and documentation procedures to be used during field activities. SOPs and SAPs may cover the following topics, as appropriate:

- procedures for selecting exact sample locations and frequency of collection
- sampling equipment operation, decontamination, and maintenance
- sample collection and processing, which includes sample collection order and homogenization procedures, sample containers, and volume required
- field QC sample and frequency criteria
- sample documentation, including chain-of-custody (COC) and field documentation forms and procedures
- sample packaging, tracking, storage, and shipment procedures.

6.4.2 Sample containers, preservation, and holding times

Containers will be prepared using EPA specified or other professionally accepted cleaning procedures. Analysis statements for containers prepared by third-party vendors will be included in the project file. Since the investigations involved with this NRDA may involve samples not amenable to typical environmental sample containers (such as whole body tissue samples), multiple types of containers may be required. Sample containers may include aluminum foil and watertight plastic bags for tissue samples and whole body samples.

When appropriate, sample coolers will contain refrigerant in sufficient quantity to maintain samples at the required temperatures until receipt at the laboratories.

6.4.3 Sample identification and labeling procedures

Before transportation, samples should be properly identified with labels, tags, or markings. Identification and labeling typically includes, but need not be limited to, the following information:

- project identification
- place of collection
- sample identification
- analysis request
- preservative
- date and time of collection
- name of sampler (initials)
- number of containers associated with the sample.

6.4.4 Field sampling forms

Field sampling forms should be described in the appropriate SOP or associated SAP, and be designed for ease of use in the field and for completeness of documentation. Forms typically must be completed in the field at the same time as the sample label. At a minimum, date, time, sampler's initials, location, and other specific field observations should be completed at the time of sampling. The FTL should review the field sampling forms, make any necessary corrections, and initial them as approved.

6.4.5 Sample storage and tracking

In the field, samples may be stored temporarily in coolers with wet or dry ice (as appropriate). Security should be maintained and proper storage should be documented in the project field notebook. Samples stored temporarily in coolers should be transported to a storage facility as soon as logistically possible. When possible, samples will be shipped directly to the appropriate laboratories from the field.

Before analysis, samples will be stored under appropriate conditions at the storage facility or laboratory (refrigerator or freezer). Security should be maintained at all times. A log book or inventory record typically is maintained for each sample storage facility refrigerator or freezer. The log books or inventory records are used to document sample movement in and out of the facility. In general, samples will be placed into a freezer and information regarding sample identification, matrix, and study will be recorded. Additional information in the record for each sample may include the date of the initial storage, subsequent removal/return events with associated dates, and initials of the person(s) handling the samples. Additional information may also include study name and special comments. If required, unused samples or extra samples will be archived in a secure location under appropriate holding conditions to ensure that sample integrity is maintained.

Documentation should allow for unambiguous tracking of the samples from the time of collection until shipment to the laboratory. The tracking system should include a record of all sample movement and provide identification and verification (initials) of the individuals responsible for the movement.

6.4.6 Geographic data collection

The usefulness of field data is often greatly enhanced by the collection of geographic data for each sample location. Sample locations should all be given distinct names and documented. If possible, a global positioning system (GPS) will be used to document the exact coordinates of each sample location. Field personnel should be trained on how to properly use the GPS and record necessary supplemental information such as the datum and units of measurement.

6.5 Sample Custody

COC procedures are adopted for samples throughout the field collection, handling, storage, and shipment process. Each sample will be assigned a unique identification label and have a separate entry on a COC record. A COC record should accompany every sample and every shipment to document sample possession from the time of collection through final disposal.

6.5.1 Definition of custody

A sample is defined as being in a person's custody if one of the following conditions applies:

- The sample is in the person's actual possession or view.
- The sample was in the person's possession and then was locked in a secure area with restricted access.
- The person placed it in a container and sealed the container with a custody seal in such a way that it cannot be opened without breaking the seal.

6.5.2 Procedures

The following information typically will be included on COC forms:

- place of collection
- laboratory name and address
- sample receipt information (total number of containers, whether COC seals are intact, whether sample containers are intact, and whether the samples are cold when received)
- signature block with sufficient room for "relinquished by" and "received by" signatures for at least three groups (field sampler, intermediate handler, and laboratory)
- sample information (field sample identifier, date, time, matrix, laboratory sample identifier, and number of containers for that sample identifier)
- name of the sampler
- airbill number of overnight carrier (if applicable)
- disposal information (to track sample from "cradle to grave")
- block for special instructions
- analysis request information.

The sample identification, date and time of collection, and request for analysis on the sample label should correspond to the entries on the COC form and in associated field log books or sampling forms.

The Data Quality Manager or designated representative is responsible for reviewing the completed COC forms. Any inconsistencies, inaccuracies, or incompleteness in the forms must be brought to the attention of the field staff completing the form. If the problem is significant, corrective action should be taken and documented. Depending on the problem, this may involve informing the laboratory that a sample ID or analysis request needs to be changed, or notifying the FTL that retraining of field staff in COC procedures is indicated. The corrective action and its outcome should be documented.

6.6 Analytical Procedures

Analytical methods will be consistent with, or equivalent to, EPA methods or some other commonly accepted or approved method, as approved by the Data Quality Manager. All laboratory equipment and instruments will be operated, maintained, calibrated, and standardized in accordance with EPA-accepted or manufacturer's practices.

Laboratory method detection limit (MDL) studies should be conducted for each matrix per analytical method, according to specifications described in 40 CFR Part 136 or other comparable professionally accepted standards. The MDL is a statistically derived, empirical value that may vary.

Laboratory QC samples, which include a method blank, replicate (matrix spike or duplicate) analyses, laboratory control sample, and SRM, will be performed at a target frequency of 1 per 20 samples per matrix per analytical batch. Method blanks should be free of contamination of target analytes at concentrations greater than or equal to the MDL, or associated sample concentrations should be greater than 10 times the method blank values. The matrix spike/matrix spike duplicate and laboratory control sample analyses should meet the specific accuracy and precision goals for each matrix and analytical method.

6.7 Calibration Procedures and Frequency

This section provides information on general calibration guidelines for laboratory and field methods.

6.7.1 Laboratory equipment

All equipment and instruments used for laboratory analyses will be operated and maintained according to the manufacturer's recommendations, as well as by criteria defined in the laboratory's SOPs. Operation, maintenance, and calibration should be performed by personnel properly trained in these procedures. Documentation of all routine and special maintenance and calibration should be recorded in appropriate log books and reference files.

Calibration curve requirements for all analytes and surrogate compounds should be met before sample analysis. Calibration verification standards, which should include the analytes that are expected to be in the samples and the surrogate compounds, should be analyzed at a specified frequency and should be within a percent difference or percent drift criterion.

6.7.2 Field equipment

All equipment and instruments used to collect field measurements will be operated, maintained, and calibrated according to the manufacturer's recommendations and by criteria defined in individual SOPs. Operation, calibration, and maintenance should be performed by personnel properly trained in these procedures. Documentation of all routine and special maintenance and calibration should be recorded in appropriate log books or reference files. Field instruments that may be used include thermometers/temperature probes, scales, pH meters, dissolved oxygen meters, and global positioning system units.

6.8 Data Validation and Reporting

6.8.1 General approach

Data generated by the laboratory and during field measurements may undergo data review and validation by an External QA Reviewer. Laboratory data may be evaluated for compliance with data quality objectives, with functional guidelines for data validation, and with procedural requirements contained in this QAPP.

6.8.2 Data reporting

Laboratories should provide sufficient information to allow for independent validation of the sample identity and integrity, the laboratory measurement system, the resulting quantitative and qualitative raw data, and all information relating to standards and sample preparation. Laboratories should provide a usable electronic version of their results in a common database format.

6.8.3 Data review and validation of chemistry data

Data review is an internal laboratory process in which data are reviewed and evaluated by a laboratory supervisor or QA personnel. Data validation is an independent review process conducted by personnel not associated with data collection and generation activities. External and independent data validation may be performed for selected sample sets as determined by the PM and Data Quality Manager. Each data package chosen for review will be assessed to determine whether the required documentation is of known and documented quality. This includes evaluating whether:

- field COC or project catalog records are present, complete, signed, and dated
- the laboratory data report contains required deliverables to document procedures.

Two levels of data validation may be performed: full or cursory validation. Initial data packages received for each sample matrix may receive full validation. This consists of a review of the entire data package for compliance with documentation and quality control criteria for the following:

- analytical holding times
- data package completeness
- preparation and calibration blank contamination
- initial and continuing calibration verifications
- internal standards
- instrument tuning standards
- analytical accuracy (matrix spike recoveries and laboratory control sample recoveries)
- analytical precision (comparison of replicate sample results)
- reported detection limits and compound quantitation
- review of raw data and other aspects of instrument performance
- review of preparation and analysis bench sheets and run logs.

Cursory validation may be performed on a subset of the data packages at the discretion of the PM and Data Quality Manager. Cursory review includes the comparison of laboratory summarized QC and instrument performance standard results to the required control limits, including:

- analytical holding times
- data package completeness
- preparation and calibration blank contamination
- analytical accuracy (matrix spike recoveries and laboratory control sample recoveries)
- analytical precision (comparison of replicate sample results).

Both the full and the cursory validation will follow documented QC and review procedures as outlined in the guidelines for data validation (U.S. EPA, 1998) and documented in validation and method SOPs. Various qualifiers, comments, or narratives may be applied to data during the validation process. These qualifier codes may be assigned to individual data points to explain deviations from quality control criteria and will not replace qualifiers or footnotes provided by the laboratory. Data validation reports summarizing findings will be submitted to the Data Quality Manager for review and approval.

Laboratory data will be evaluated for compliance with data quality objectives. Data usability, from an analytical standpoint, may be evaluated during the data evaluation. The data users (the PI, PM, AM) will determine the ultimate usability of the data.

6.9 Performance and System Audits

A Data Quality Manager or designee will be responsible for coordinating and implementing any QA audits that may be performed. Checklists may be prepared that reflect the system or components being audited, with references to source of questions or items on the checklist. Records of all audits and corrective actions should be maintained in the project files.

6.9.1 Technical system audits

Technical System Audits (TSAs) are qualitative evaluations of components of field and laboratory measurement systems, including QC procedures, technical personnel, and QA management. TSAs determine if the measurement systems are being used appropriately. TSAs are normally performed before or shortly after measurement systems are operational, and during the program on a regularly scheduled basis. TSAs involve a comparison of the activities described in the SAP and SOPs with those actually scheduled or performed. Coordination and implementation of any TSAs will be the responsibility of the Data Quality Manager or designee.

Analytical data generation (laboratory audit)

Laboratory audits may be performed to determine whether the laboratory is generating data according to all processes and procedures documented in the associated SAPs, QAPP, SOPs, and analytical methods. Laboratory audits can be performed by an External QA Reviewer, a Data Quality Manager, or their designee.

Field audits

Field audits may be performed to determine whether field operations and sample collection are being performed according to processes and procedures documented in the SAP, QAPP, and SOPs.

6.9.2 Performance evaluation audits

Performance evaluation audits are quantitative evaluations of the measurement systems of a program. Performance evaluation audits involve testing measurement systems with samples of known composition or behavior to evaluate precision and accuracy, typically through the analysis of standard reference materials. These may be conducted before selecting an analytical laboratory.

6.10 Preventative Maintenance Procedures and Schedules

Preventative maintenance typically is implemented on a scheduled basis to minimize equipment failure and poor performance. In addition to the scheduled calibration procedures described above, the following procedures may be followed.

- Thoroughly clean field equipment before returning to the office. The equipment generally should be stored clean and dry.
- Replaceable components such as pH electrodes and dissolved oxygen membranes should be inspected after and before each use, and replaced as needed to maintain acceptable performance.
- Equipment that is malfunctioning or out of calibration will be removed from operation until repaired or recalibrated.

6.11 Procedures Used to Assess Data Usability

Data usability ultimately is a function of study methods, investigator expertise and competence, and intended uses. QA/QC procedures are designed to help ensure data usability but, in themselves, neither assure data usability nor — if not implemented — indicate that data are not useable or valid. Data validity and usability will ultimately be determined by the PI, PM, and AM using their best professional judgment. Independent data validation, consultations with Data Quality Managers, and review of project-wide databases for data compatibility and consistency can be used to support usability evaluations. The usability and validity of existing and historical data, which were not collected pursuant to the QAPP presented in this assessment plan, will be determined by the AM, PM, PIs, and trustee technical staff using their best professional judgment.

6.12 Corrective Actions

6.12.1 Definition

Corrective actions consist of the procedures and processes necessary to correct and/or document situations where data quality and/or QA procedures fall outside of acceptance criteria or targets. [These criteria/targets may be numeric goals such as those discussed in Section 6.3, or procedural requirements such as those presented throughout the QAPP and other project documents (e.g., SAPs and SOPs)].

The goal of corrective action is to identify as early as possible a data quality problem and to eliminate or limit its impact on data quality. The corrective action information typically is provided to a Data Quality Manager for use in data assessment and long-term quality management. Corrective action typically involves the following sequential steps:

- discovering any nonconformance or deviations from data quality objectives or the plan
- identifying the party with authority to correct the problem
- planning and scheduling an appropriate corrective action
- confirming that the corrective action produced the desired result
- documenting the corrective action.

6.12.2 Discovery of nonconformance

The initial responsibility of identifying nonconformance with procedures and QC criteria lies with the field personnel and bench-level analysts. Performance and system audits are also designed to detect these problems. However, anyone who identifies a problem or potential problem should initiate the corrective action process by, at the least, notifying a PI or Data Quality Manager of his or her concern.

Deviations from SAP, QAPP, or SOP procedures are sometimes required and appropriate because of field or sample conditions. Such deviations should be noted in field or laboratory logbooks and their effect on data quality evaluated by a PI and Data Quality Manager. Occasionally, procedural changes are made during an investigation because method improvements are identified and implemented. Even though these procedural improvements are not initiated because of nonconformance, they are procedural deviations and typically should be documented.

6.12.3 Planning, scheduling, and implementing of corrective action

Appropriate corrective actions for routine problems depend on the situation and may range from documentation of the problem to resampling and reanalysis to the development of new methods. When the corrective action is within the scope of these potential actions, the bench-level analyst or the field staff can identify the appropriate corrective action and implement it. Otherwise, the corrective action should be identified and selected by the PM, the FTL, the Laboratory Manager, or the Data Quality Manager.

6.12.4 Confirmation of the result

While a corrective action is being implemented, additional work dependent on the nonconforming data should not be performed. When the corrective action is complete, the situation should be evaluated to determine if the problem was corrected. If not, new corrective actions should be taken until no further action is warranted, either because the problem is now corrected or because no successful corrective action has been found.

6.12.5 Documentation and reporting

Corrective action documentation may consist of the following reports or forms:

- corrective action forms initiated by project staff that will be collected, evaluated, and filed by the Data Quality Manager
- corrective action log maintained by the Data Quality Manager to track the types of nonconformance problems encountered and successful completion of corrective actions
- corrective action plans, if needed, to address major nonconformance issues
- performance and systems audit reports, if such audits are performed
- corrective action narratives included as part of data reports from independent laboratories
- corrective action forms initiated by laboratory staff and summarized in the report narrative.

6.12.6 Laboratory-specific corrective action

The need for corrective action in the analytical laboratory may come from several sources: equipment malfunction, failure of internal QA/QC checks, method blank contamination, failure of performance or system audits, and/or noncompliance with QA requirements.

When measurement equipment or analytical methods fail QA/QC checks, the problem should immediately be brought to the attention of the appropriate laboratory supervisor in accordance with the laboratory's SOP or Quality Assurance Manual. If failure is due to equipment malfunction, the equipment should be repaired, the precision and accuracy should be reassessed, and the analysis rerun.

All incidents of QA failure and the corrective action tasks should be documented, and reports should be placed in the appropriate project file. Corrective action should also be taken promptly for deficiencies noted during spot checks of raw data. As soon as sufficient time has elapsed for a corrective action to be implemented, evidence of correction of deficiencies should be presented to a Data Quality Manager or PI.

Laboratory corrective actions may include, but are not limited to:

- reanalyzing the samples, if holding time criteria permit and if sample volume is available
- resampling and analyzing
- evaluating and amending sampling analytical procedures
- accepting data and acknowledging the level of uncertainty.

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